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CMCiB Comparative Medicine & Bioimage Centre of Catalonia

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Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

Situation report 103

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Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ *a*: the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ *K*: the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to data-points. We also discuss a specific issue every day.

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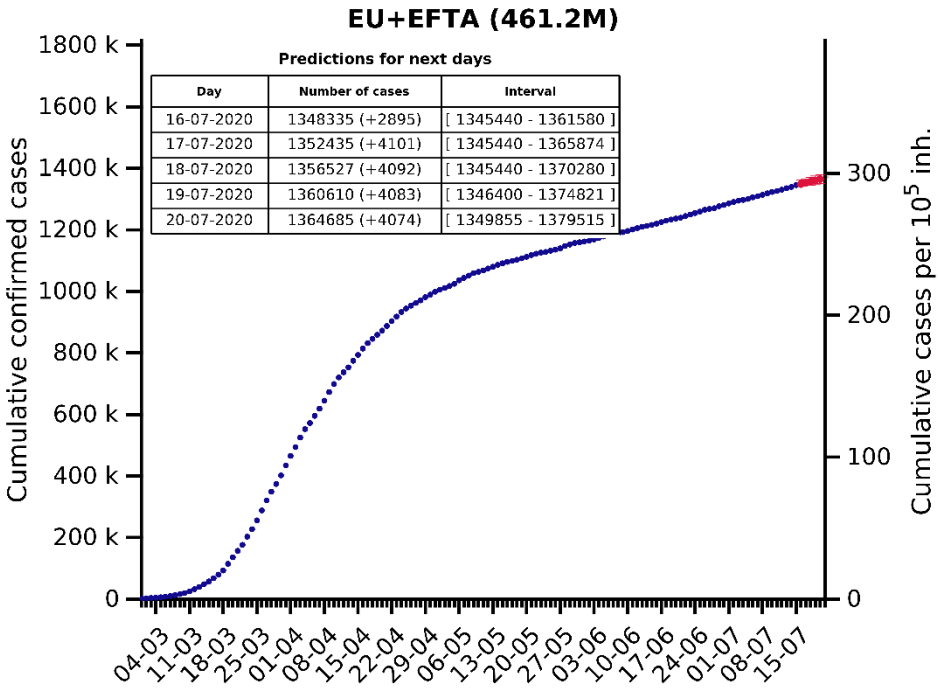
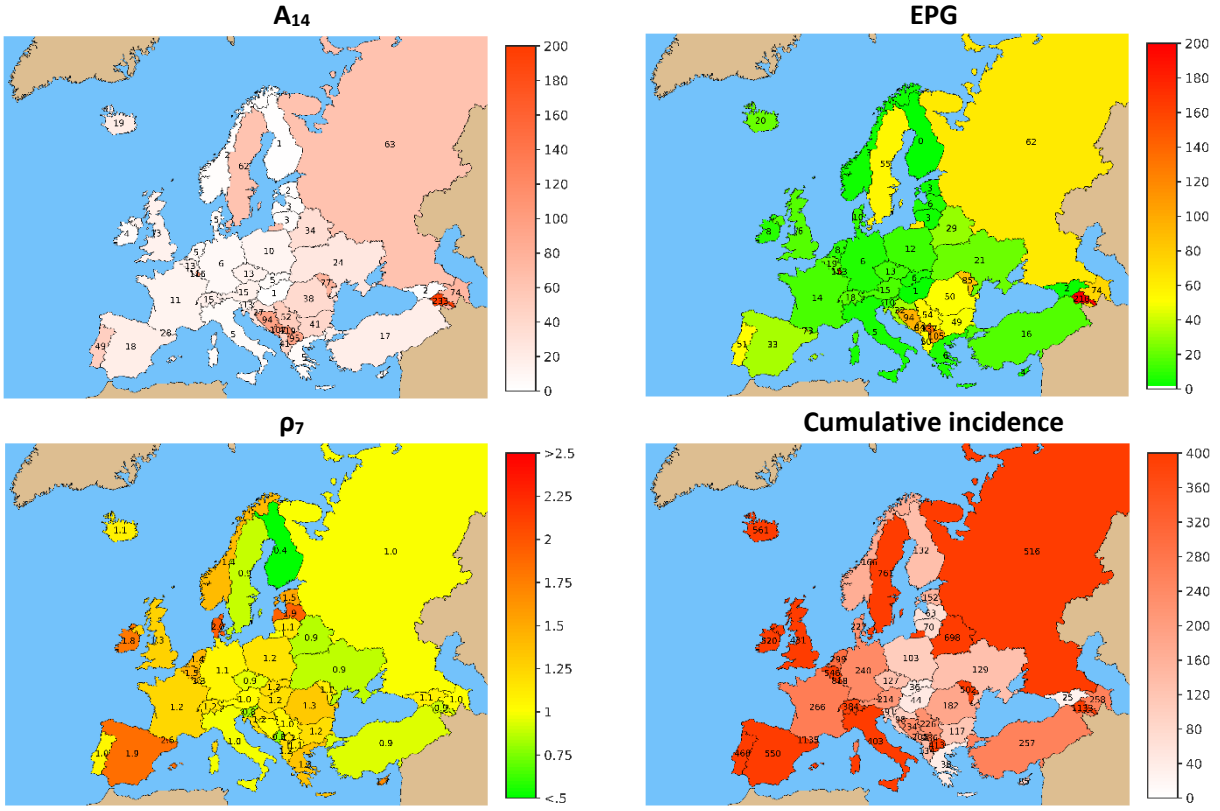
(0) Executive summary – Dashboard

Situation and highlights

The virus is still present in EU+EFTA+UK countries. Countries started to ease the control measures a two or three months ago. Now, it is necessary to increase the surveillance again to face local outbreaks and, if necessary, to implement control measures again. New control measures may not need to be as hard as in previous months. Nevertheless, if the new spread of covid-19 is not slowed down, it is not unlikely to have to take major confinement measures again.



Currently 24 countries have a ρ_7 greater than 1, from **Denmark** with 1.96 and **Latvia** 1.93 to **Austria** with 1.01. Only 5 countries have a ρ_7 below 1 (**Italy**, **Czech Republic**, **Sweden**, **Slovenia**, **Finland**). **Sweden** seems to be improving, although the reported data show some days without information, despite still being the country with the highest A_{14} with 472 active cases per 100,000 inhab. **Luxembourg** has an A_{14} of 286 per 100,000 inhabitants, which places the country at the second in the A_{14} rank, but its ρ_7 of 1.32 situates it at high level of risk.



Situation and trends per country

Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. Last column (**EPG_{EST}**) is assessed with **estimated real 14-day attack rate** (see report from 22/04 for details). **EPG_{REP}** is calculated with **data reported by countries**. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively. **Data from 2nd July.**

	Reported data								Indexes			
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 [1]	EPG_{REP} [2]	EPG_{EST} [3]	Biocom-Cov degree
Spain	258.855	558,5	28.416	61,3	8.752	18,9	98.306	209,0	1,57	30	329	4
Italy	243.736	410,1	35.017	58,9	2.775	4,7	39.827	65,9	0,98	5	65	2
Germany	200.843	245,2	9.082	11,1	5.169	6,3	24.137	28,8	1,05	7	30	2
France	173.838	268,6	30.138	46,6	7.460	11,5	133.699	204,8	1,24	14	253	3
Sweden	76.877	781,4	5.593	56,9	6.238	63,4	47.594	471,3	0,89	56	418	5
Belgium	63.238	556,8	9.795	86,2	1.511	13,3	23.712	204,6	1,46	19	298	3
Netherlands	51.296	302,0	6.128	36,1	939	5,5	11.120	64,9	1,42	8	92	2
Portugal	47.765	460,5	1.679	16,2	4.983	48,0	18.053	177,0	1,05	50	185	5
Poland	39.054	102,2	1.605	4,2	3.908	10,2	16.719	44,2	1,16	12	51	3
Romania	35.003	177,0	1.971	10,0	7.257	36,7	45.559	236,8	1,32	48	312	5
Switzerland	33.205	387,5	1.687	19,7	1.321	15,4	6.858	79,2	1,16	18	92	3
Ireland	25.698	543,8	1.749	37,0	209	4,4	1.431	29,0	1,79	8	52	2
Austria	19.268	221,2	711	8,2	1.316	15,1	5.166	57,4	1,01	15	58	3
Czech Republic	13.612	128,3	355	3,3	1.434	13,5	4.055	37,9	0,95	13	36	3
Denmark	13.124	229,8	610	10,7	309	5,4	1.469	25,4	1,96	11	50	2
Norway	9.011	167,9	254	4,7	116	2,2	342	6,3	1,40	3	9	2
Bulgaria	8.144	114,2	293	4,1	2.829	39,7	13.487	194,1	1,19	47	232	5
Finland	7.293	132,5	328	6,0	52	0,9	215	3,9	0,44	0	2	1
Luxembourg	5.122	889,2	111	19,3	727	126,2	1.789	285,7	1,32	167	377	7
Hungary	4.279	43,9	595	6,1	113	1,2	1.597	16,5	1,19	1	20	1
Croatia	4.039	95,9	119	2,8	1.127	26,8	4.071	99,2	1,18	32	117	4
Greece	3.939	35,2	193	1,7	481	4,3	2.554	24,5	1,35	6	33	2
Estonia	2.016	153,7	69	5,3	26	2,0	NA	NA	1,52	3	NA	1
Slovakia	1.951	35,8	28	0,5	251	4,6	NA	NA	1,20	6	NA	2
Iceland	1.914	525,4	10	2,7	64	17,6	NA	NA	1,08	19	NA	3
Lithuania	1.902	65,4	79	2,7	77	2,6	NA	NA	1,14	3	NA	2
Slovenia	1.897	91,3	111	5,3	264	12,7	1.682	80,9	0,81	10	66	3
Latvia	1.179	59,8	31	1,6	57	2,9	NA	NA	1,93	6	NA	2
Cyprus	1.031	88,1	19	1,6	32	2,7	NA	NA	1,68	5	NA	2
Malta	674	157,1	9	2,1	4	0,9	NA	NA	NA	NA	NA	0
Liechtenstein	85	220,5	1	2,6	2	5,2	NA	NA	NA	NA	NA	0
Scale												
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	100	1000	
	Best	Best	Best	Best	Best	Best	Best	Best	0,0	0	0	

Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher)

[1] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [2,3] EPG stands for Effective Growth Potential. EPG_{REP} is the product of attack-rate of last 14 days per 10^5 inhabitants by ρ_7 (empiric reproduction number). EPG_{EST} is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and ρ_7. Biocom-Cov degree is an epidemiological situation scale based on the level of last week's mean daily new cases (https://upcommons.upc.edu/handle/2117/189661, https://upcommons.upc.edu/handle/2117/189808).

Analysis: Dynamics of new outbreaks in three Catalan cities (I).

European countries are, in general, dealing with a similar situation: most of them have successfully overcome the first wave, and they are now trying to extinguish local outbreaks that are appearing in their regions. The strategy is clear: test and trace while incident cases are low, and new restrictions when certain thresholds are overcome. These thresholds may vary from country to country, as they are mainly determined by the testing and tracing capacities. This means that daily testing level is important (i.e., number of PCR tests that can be performed per day and per 100,000 inhabitants), but that the number of available health workers to carry out the tracing and isolation of index cases' contacts is important as well. This is the only way to break transmission chains, one by one.

The epidemics in Lleida, L'Hospitalet and Barcelona

The situation in Catalunya (Spain) has worsen since country-level restrictions were fully removed, on 21st June. The de-escalation process started on 2nd May and took almost 2 months, during which the restrictions were gradually eased in a heterogeneous manner, depending on the situation of each region. Last weeks, a region in Western Catalunya (Segrià) started showing symptoms of significant growth. The capital of this region is Lleida, with almost 140,000 inhabitants. Last week, two most populated cities have also started showing a change in previous control trend: L'Hospitalet de Llobregat (265,000 inhabitants) and Barcelona (1,640,000 inhabitants).

Figure 1 shows the evolution of the three cities since middle-March, in terms of 7-day cumulative incidence. We also indicate the days at which the process of gradual easing of restrictions started and the moment at which it finished.

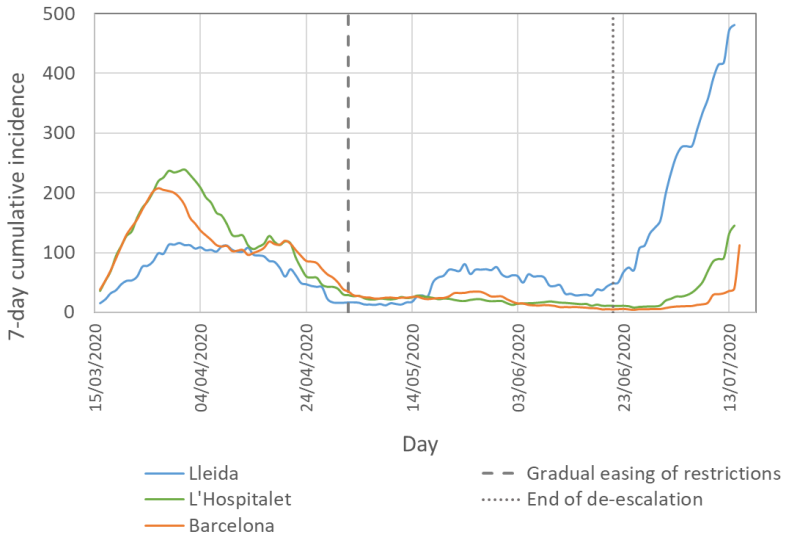


Figure 1: Evolution of the 7-day cumulative incidence in the Catalan cities of Lleida, L'Hospitalet de Llobregat and Barcelona, together with the starting and end days of the de-escalation process.

As shown, **the three cities had successfully overcome the first wave when the de-escalation process started**. During the process, Lleida was allowed to de-escalate faster at an initial stage, but this was slowed down when a new increase was observed. Once in the final phase of the de-escalation, Lleida showed new

symptoms of growth that become uncontrolled in a few days. This was discussed in a previous report[1]. After a couple of weeks, also L'Hospitalet de Llobregat started showing symptoms of a new growth. Last week, Barcelona has started showing an increase in new cases as well.

The increase in testing capacity: more and milder cases are diagnosed

It is worth to mention that the 7-day **cumulative incidences that are currently being achieved cannot be directly compared with those of the first wave**. The testing capacity has increased a factor 4, in Catalunya (Figure 2). Therefore, the same number of reported cases indicate a different epidemiological situation. If the diagnostic rate was between 5-10% in March-April, it has raised up to 20-30% currently. This **increase in testing ratio could also explain the generalized mild symptoms of current new cases**. In March-April, only serious cases were diagnosed. The front line were hospitals, and PCRs were mostly performer there. Now, diagnosis capacity has been mainly transferred to primary care points, and only serious cases are redirected to hospitals. Therefore, current increase in new cases is affecting those primary care facilities. In these towns, many of them are collapsed.

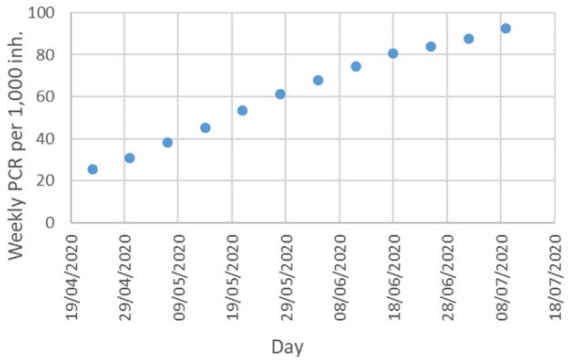


Figure 2: Weekly number of PCR tests per 1,000 inhabitants in Catalunya.

The epidemics in these cities through the index Effective Potential Growth (EPG)

We have successfully used the EPG index to analyze the epidemiological situation of regions and countries. This index is the product between empiric reproduction number (ρ_7), which is a measurement of the rate at which the epidemic is propagating, and 14-day cumulative incidence (A_{14}), which is a measurement of the number of active cases (contagious people). As discussed in previous reports, **we have situated the threshold for high epidemiological risk at an EPG = 100**. This level accounts for an expected growth that would overcome the test and trace capacity in most European countries. Figure 3 shows the evolution of this index in the three cities during the whole epidemic. The EPG = 100 level is also indicated, and the intermediate growth in Lleida that required the slowing down of the de-escalation process is shown as well.

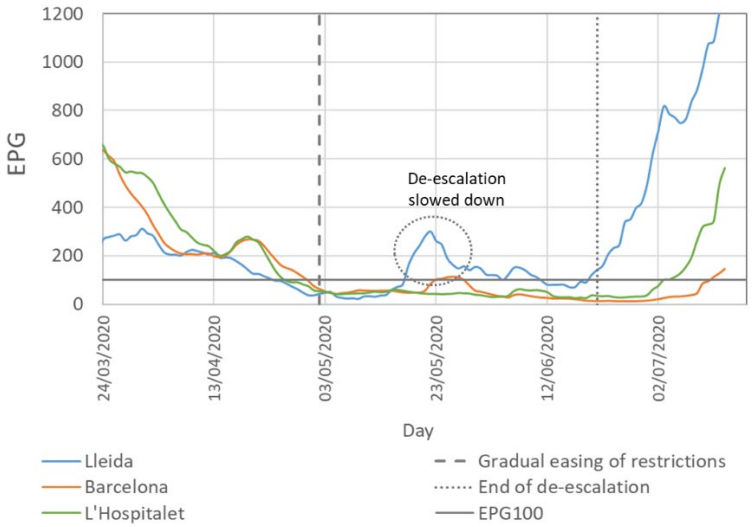


Figure 3: Evolution of EPG in the Catalan cities of Lleida, L'Hospitalet de Llobregat and Barcelona, together with the starting and end days of the de-escalation process.

[1] https://upcommons.upc.edu/handle/2117/192557

EPG dynamics and new restriction measures

Figure 3 strengthens the **validity of the EPG = 100 threshold. It is not an absolute on-off threshold, but it delimits the control-uncontrol zones pretty well**. When the EPG reaches this level, the probability of significant growth increases. Lleida's EPG is less robust because of lower population, which makes this index to be more sensitive to smaller changes.

Let us zoom in the last month (Figure 4). The situation in the three cities has required the intervention of authorities for implementing new restrictions, once they realized that community transmission was present. On 7th July, the Catalan government implemented a safe perimeter around Lleida's county (Segrià) which forbids the movement of people in and out for reason other than work, because some exported cases had been detected in other Catalan regions. This did not stop the worsen of the situation. Therefore, on 14th July the government implemented a set of measures regarding mass gathering prevention, internal mobility and restaurants capacity, among others. Similar measures were applied on 14th in L'Hospitalet de Llobregat, after a few days with EPG>100. **These measures have been extended today to the whole metropolitan area around Barcelona, including the capital**. Legislation is still not ready, and most of those control measures remain as recommendations, waiting for their approval by justice services.

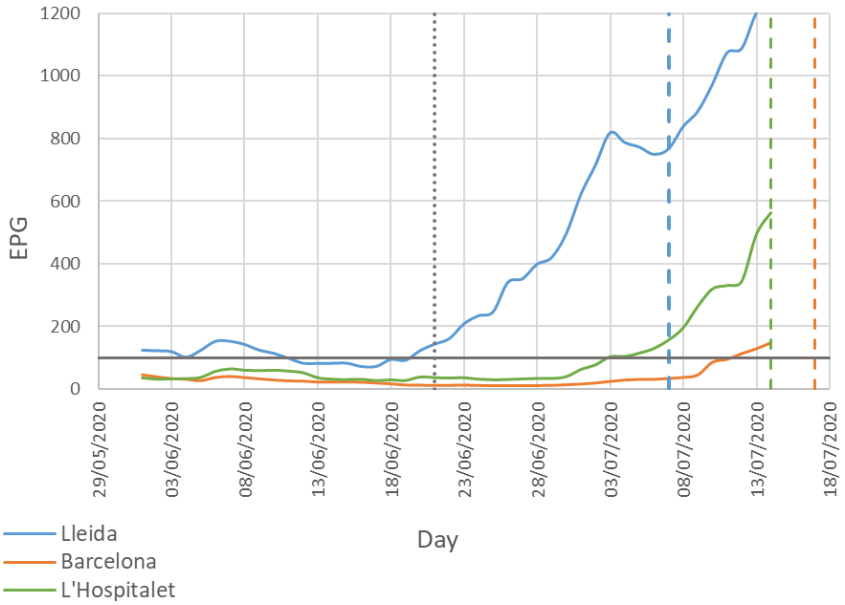


Figure 4: Evolution of EPG in the Catalan cities of Lleida, L'Hospitalet and Barcelona since beginning of June. Grey dotted line indicates the end of the de-escalation process. Colored dashed lines indicate first restriction measures in each city. The threshold EPG = 100 is also indicated.

As shown in Figure 4, **perimetric confinement of Lleida's county has not managed to control the growth**. In fact, this measure was applied 17 days after the overcoming of EPG = 100, which **was probably too late**. The next measure, which limits mobility and meetings, was applied 24 days after that point. It will probably still take another week for the effects to be seen in reported data. In L'Hospitalet de Llobregat, measures were taken before: only 9 days after the overcoming of the threshold. Finally, Barcelona have only been 3 days above EPG = 100 before measures have been implemented. **Next days we will be able to observe the delay between these measures and their effect, as well as the magnitude of such effect, which will obviously depend on the current situation.**

It is also interesting to compare the evolution of these cities once the EPG = 100 threshold is overcome. Figure 5 situates time origin at the day at which EPG gets higher than 100 for each city. Then, **we can visualize how the EPG starts a significant increase from that point**. In fact, the evolution of L'Hospitalet de Llobregat is being similar to that one of Lleida but with a delay of 2 weeks. Nevertheless, the population density in

L'Hospitalet is huge, and this could accelerate the propagation of the epidemic the next days, as it is insinuated by last points. The evolution of Barcelona cannot be observed yet, but it could be hopefully modulated by the effect of earlier control measures.

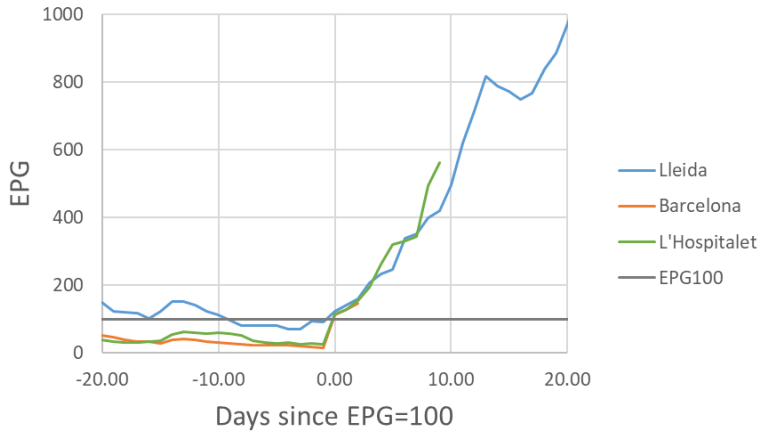


Figure 5: Evolution of EPG in the Catalan cities of Lleida, L'Hospitalet de Llobregat and Barcelona before and after the overcoming of EPG = 100 threshold.

New outbreaks in the risk diagrams

Risk diagrams are a good way to visualize the aforementioned dynamics, as well. Next, we show the risk diagrams of these cities for the last month (Figure 6). Background color is set according to the EPG scale, situating the red zone where EPG > 100. It can be observed how Lleida has spent more than 3 weeks in the red zones and no improvement symptoms are shown yet. L'Hospitalet de Llobregat entered the red zone 10 days ago, while Barcelona has only spent 3 days in the risk zone. It is clear again that, **once in the red zone, the situation worsens rapidly**.

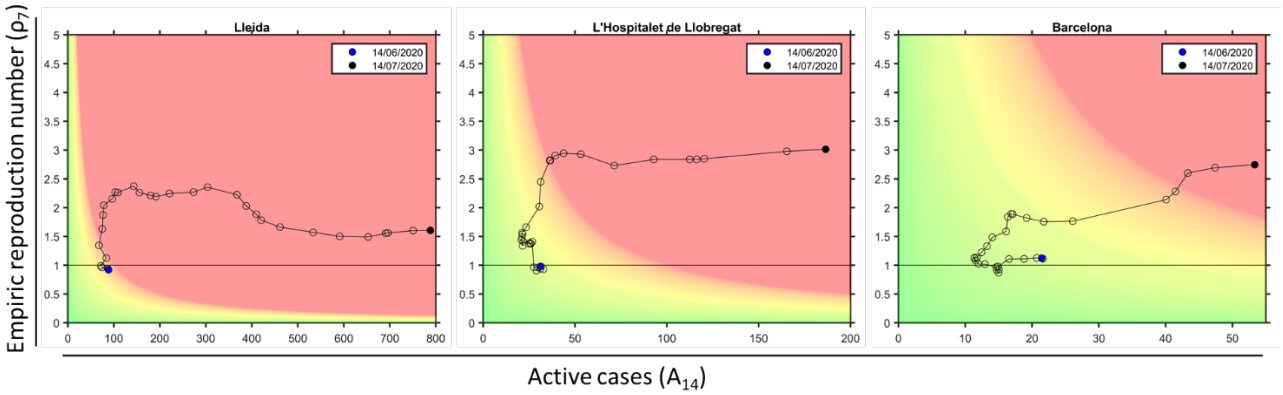


Figure 6: Risk diagrams of Lleida, L'Hospitalet de Llobregat and Barcelona corresponding to last 30 days.

Final conclusions

The situation in Catalunya is worrying. There was a generalized idea among population about a new outbreak coming in October, but it seems that the necessary material and personal resources to overcome summer's outbreaks were not ready. Different estimations point to the need for 2,000 health workers and trackers fully devoted to the test and trace strategy, but primary health care centers do not have enough means to face current situation. At present, hospitalizations are still low in Barcelona and L'Hospitalet de Llobregat, but the main hospital in Lleida is already working with 3 floors entirely devoted to Covid-19. It is expected that earlier control measures in Barcelona prevent serious cases to increase significantly.

Situation and trends in other countries

Table of current situation in a sample of non-EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively. **Data from 2nd July.**

	Reported data								Indexes			
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 (1)	EPG_{REP} (2)	EPG_{EST} (3)	Biocom-Cov degree
United States of America	3.576.221	1.080,4	138.358	41,8	836.342	252,7	3.711.039	1.121,2	1,15	290	1.286	9
Brazil	2.012.151	946,6	76.688	36,1	515.293	242,4	2.130.230	1.002,2	1,02	247	1.022	9
India	1.003.832	74,2	25.602	1,9	378.288	28,0	1.099.731	81,3	1,17	33	95	4
Russia	752.797	515,8	11.937	8,2	91.632	62,8	NA	NA	0,99	62	NA	6
Peru	341.586	1.036,0	12.615	38,3	49.582	150,4	204.338	619,7	1,03	156	641	8
Mexico	324.041	251,3	37.574	29,1	85.530	66,3	1.070.218	830,1	0,99	66	822	6
Chile	323.698	1.693,3	7.290	38,1	39.157	204,8	93.923	491,3	0,87	178	426	8
Iran	267.061	318,0	13.608	16,2	34.198	40,7	180.996	215,5	0,95	39	205	5
Pakistan	259.999	117,7	5.475	2,5	38.103	17,2	83.630	37,9	0,82	14	31	3
Saudi Arabia	243.238	698,7	2.370	6,8	45.630	131,1	NA	NA	0,83	108	NA	7
Argentina	114.757	253,9	2.112	4,7	44.829	99,2	95.194	210,6	1,35	134	284	7
Canada	109.253	289,5	8.827	23,4	4.493	11,9	37.749	100,0	1,17	14	118	3
Qatar	105.447	3.660,0	152	5,3	7.550	262,1	NA	NA	0,85	224	NA	8
Ecuador	71.365	404,5	5.207	29,5	11.897	67,4	101.770	576,8	1,20	81	695	6
Belarus	65.915	697,6	485	5,1	3.217	34,0	NA	NA	0,86	29	NA	4
	Scale											
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	100	1000	
	Best	Best	Best	Best	Best	Best	Best	Best	0,0	0	0	

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Time indicators by country

These tables summarize a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold). **Data from 2nd July.**

EU+EFTA+UK countries

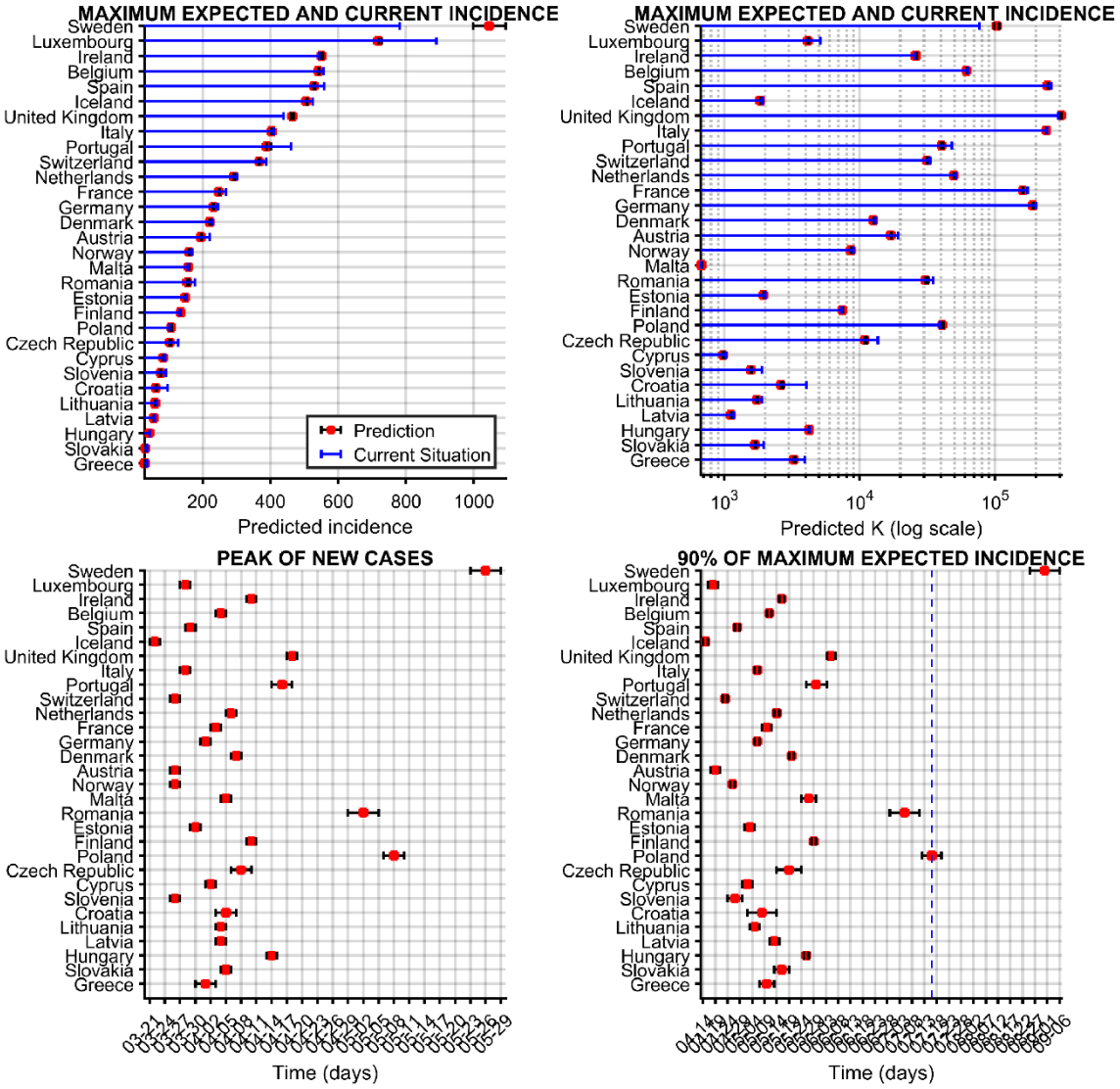
Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	145	11	16
Germany	139	12	17
France	138	10	20
Spain	138	8	12
Belgium	135	10	15
United Kingdom	134	10	12
Netherlands	133	11	20
Sweden	133	10	28
Norway	133	2	7
Switzerland	133	8	11
Austria	131	10	14
Denmark	130	4	30
Czech Republic	127	11	94
Finland	127	12	46
Greece	127	18	NA
Iceland	127	5	15
Portugal	126	9	15
Slovenia	126	6	NA
Estonia	125	5	30
Ireland	125	8	18
Poland	125	17	101
Romania	125	15	66
Luxembourg	122	6	7
Slovakia	121	24	NA
Bulgaria	120	30	88
Croatia	120	12	NA
Hungary	119	20	NA
Latvia	119	12	NA
Lithuania	118	9	NA
Malta	117	9	35
Cyprus	116	12	NA

Other countries

Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Iran	142	11	42
United States of America	137	8	15
Canada	128	11	27
Qatar	128	3	31
Brazil	125	20	34
Saudi Arabia	124	21	29
Chile	123	13	36
Pakistan	123	35	59
India	123	38	NA
Russia	122	15	24
Peru	122	18	22
Ecuador	122	10	30
Mexico	121	25	47
Argentina	120	39	54
Belarus	109	10	18

Long-term predictions

Evaluated with the **whole historical series**. Up-left: Predictions of maximum incidences per country **at the end of the first wave** (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country at the end of the first wave (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date.



Final expected value for EU+EFTA+UK as a whole is not shown any more, since we are in the tail (see Analysis section in Report #87, https://upcommons.upc.edu/handle/2117/190497).

Situation and trends in Italian and Spanish regions

Italy

Data from **17th July**

	Reported data								Indexes			
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 (1)	EPG_{REP} (2)	EPG_{EST} (3)	Biocom-Cov degree
Lombardia	95,371	949.7	16,778	167.1	1,148	11.4	20,345	202.2	0.83	9	167	3
Piemonte	31,530	723.8	4,119	94.6	136	3.1	1,791	41.1	0.64	2	26	2
Emilia Romagna	29,087	652.3	4,273	95.8	525	11.8	7,664	171.9	0.98	12	168	3
Veneto	19,525	398.0	2,047	41.7	211	4.3	2,247	45.8	1.93	8	88	2
Toscana	10,356	277.7	1,129	30.3	89	2.4	973	26.1	1.32	3	34	2
Liguria	10,052	648.2	1,565	100.9	65	4.2	1,001	64.5	1.03	4	66	2
Lazio	8,399	142.9	849	14.4	258	4.4	2,603	44.3	1.15	5	51	2
Marche	6,809	446.4	987	64.7	20	1.3	293	19.2	1.50	2	29	1
Trento	4,881	455.2	405	37.8	10	0.9	93	17.2	0.69	1	12	0
Campania	4,803	82.8	433	7.5	91	1.6	845	14.6	0.83	1	12	1
Puglia	4,547	112.9	548	13.6	14	0.3	169	4.2	NA	NA	NA	1
Friuli Venezia Giulia	3,346	275.3	345	28.4	28	2.3	281	23.1	1.39	3	32	2
Abruzzo	3,334	254.2	468	35.7	36	2.7	504	38.4	1.50	4	57	2
Sicilia	3,136	62.7	283	5.7	45	0.9	414	8.3	3.10	3	26	2
Bolzano	2,682	2,496.4	292	271.8	40	37.2	427	82.0	2.27	84	186	3
Umbria	1,454	164.8	80	9.1	8	0.9	NA	NA	1.90	2	NA	1
Sardegna	1,377	84.0	134	8.2	8	0.5	82	5.0	2.14	1	11	1
Calabria	1,231	63.2	97	5.0	49	2.5	NA	NA	3.26	8	NA	2
Valle dAosta	1,196	952.2	146	116.2	0	0.0	3	2.6	0.00	0	0	0
Molise	446	145.9	23	7.5	1	0.3	NA	NA	0.43	0	NA	1
Basilicata	405	72.0	27	4.8	1	0.2	NA	NA	0.00	0	NA	2

Scale											
Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	100	1000
Best	Best	Best	Best	Best	Best	Best	Best	Best	0.0	0	0

Spain

Data from **8th July**. Symptoms onset date.

	Reported data				Indexes		
Autonomous regions	Cumulative cases	Attack rate /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	ρ_7 (1)	EPG_{REP} (2)	Biocom-Cov degree
Madrid	72,779	1,096.0	564	8.5	0.94	8	2
Catalunya	59,019	780.1	2,828	37.4	1.51	56	6
Castilla y Leon	26,738	1,110.3	147	6.1	0.74	5	2
Castilla-La Mancha	22,182	1,089.8	219	10.8	0.99	11	3
Andalucia	16,999	201.7	367	4.4	0.90	4	2
Comunitat Valenciana	15,023	302.0	190	3.8	1.13	4	2
Euskadi	14,737	676.6	159	7.3	1.41	10	3
Galicia	10,922	404.5	210	7.8	1.99	15	3
Navarra	7,858	1,209.0	74	11	1.3	15	3
Aragon	7,178	543.5	540	40.9	1.1	45	5
Extremadura	5,709	535.9	71	6.7	1.87	12	2
La Rioja	4,004	1,276.9	8	2.6	1.07	3	2
Murcia	2,545	171.1	72	4.8	0.88	4	2
Canarias	2,521	114.2	28	1.3	2.83	4	1
Asturias	2,437	238.4	2	0.2	0.43	0	0
Baleares	2,378	200.2	55	4.6	0.71	3	2
Cantabria	2,361	405.9	14	2.4	1.44	3	2
Ceuta	222	261.7	0	0.0	NA	NA	0
Melilla	140	165.3	0	0.0	NA	NA	0

Scale					
Worst	Worst	Worst	Worst	2.0	200
Best	Best	Best	Best	0.0	0

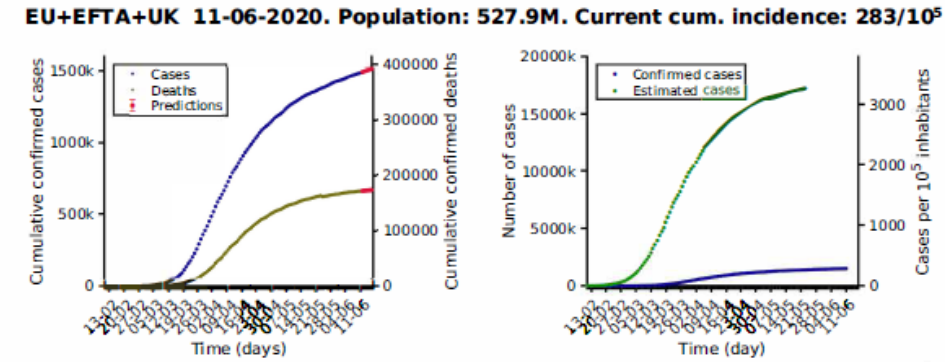
Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

(1) ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. (2,3) EPG stands for Effective Growth Potential. EPG_{REP} is the product of attack-rate of last 14 days per 10^5 inhabitants by ρ_7 (empiric reproduction number). EPG_{EST} is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and ρ_7. Biocom-Cov degree is an epidemiological situation scale based on the level of last week's mean daily new cases (https://upcommons.upc.edu/handle/2117/189661, https://upcommons.upc.edu/handle/2117/189808).

Long-term predictions are not shown any more, since all Italian and Spanish regions are already in the tail (see Analysis section in Report #87, https://upcommons.upc.edu/handle/2117/190497).

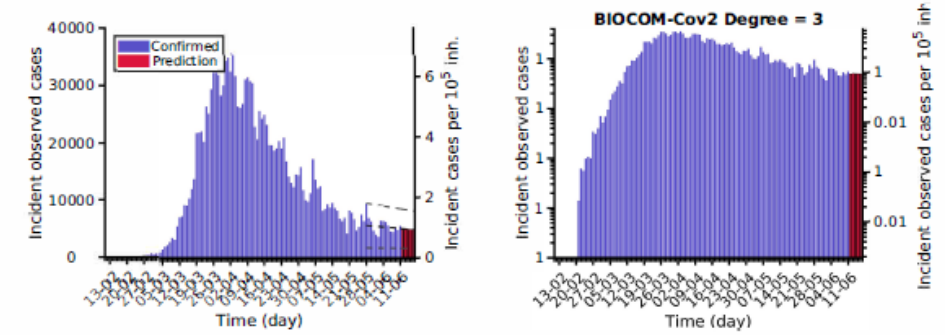
Legend: Countries' reports details

Reported cumulative cases (blue) and deaths (brown), together with predictions (red



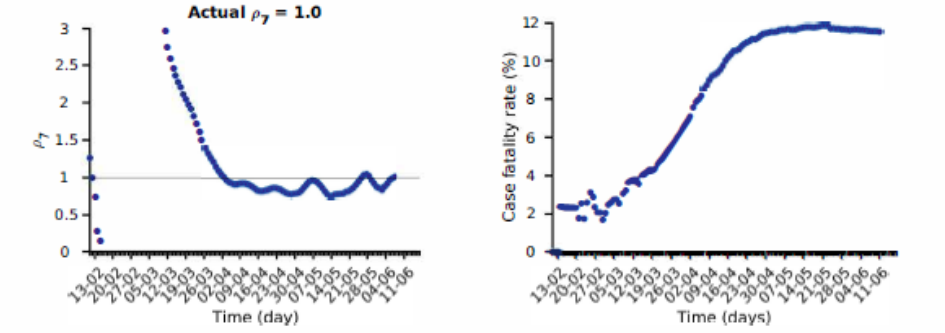
Estimated and reported cases.

Incident observed cases and predictions.



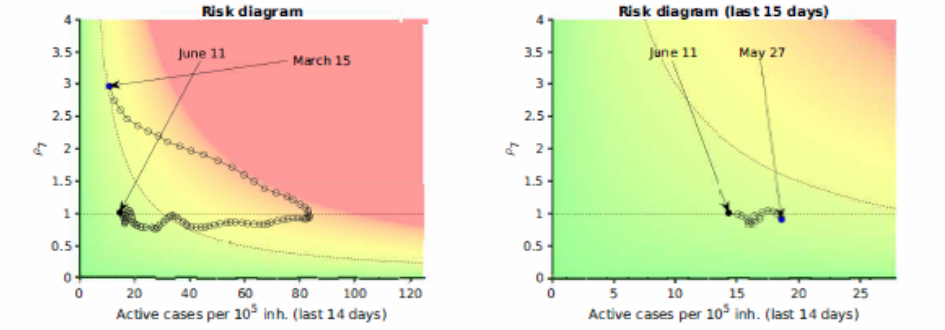
Incident observed cases in a logarithmic scale, with Biocom-Cov degree.

Evolution of empiric reproductive number ρ_7



Case fatality rate

Risk diagram

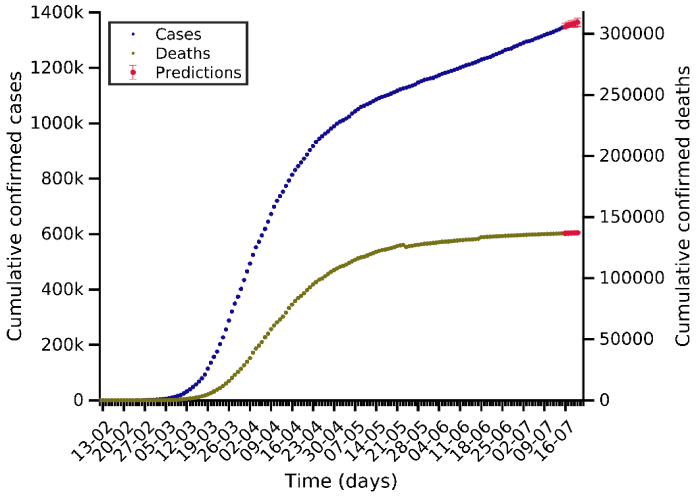


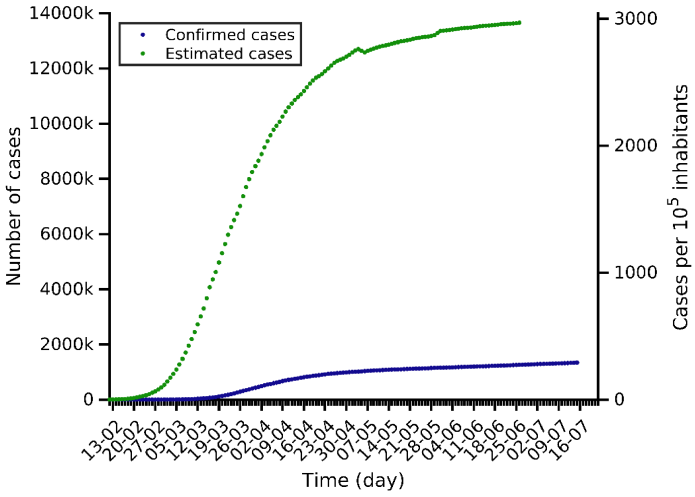
Risk diagram of last 15 days

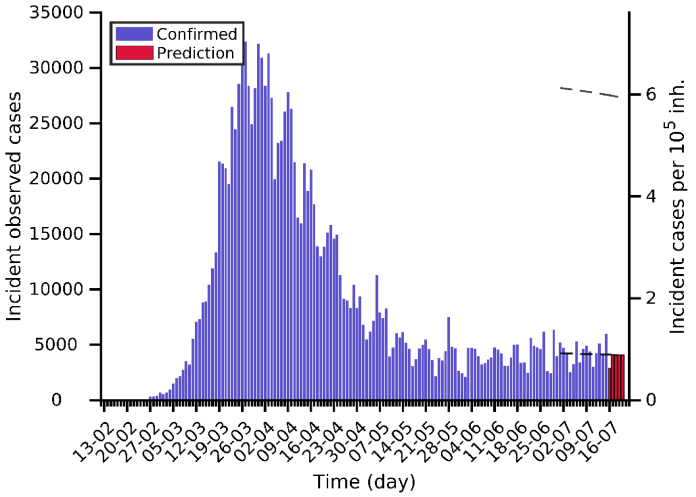
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

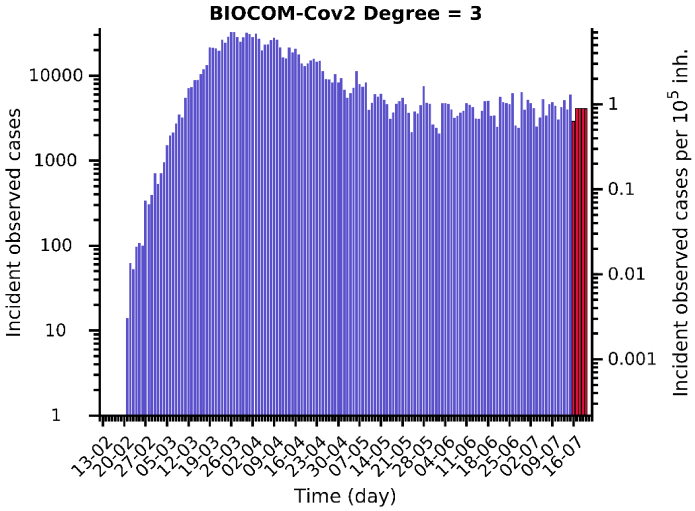
Data obtained from https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

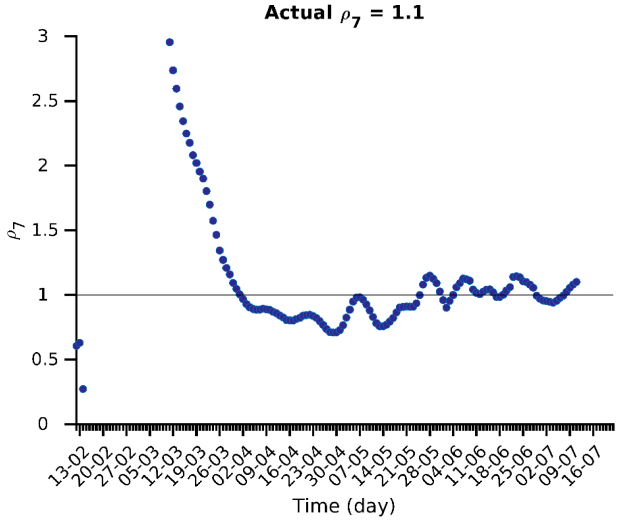
EU+EFTA 16-07-2020. Pop: 460.0M. Cumulative incidence: 293/10⁵

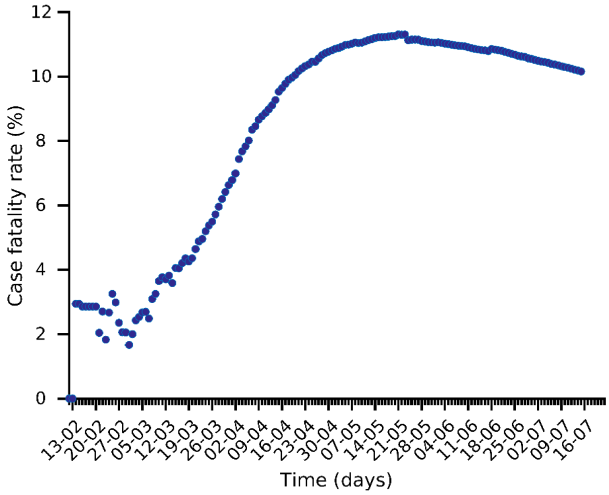


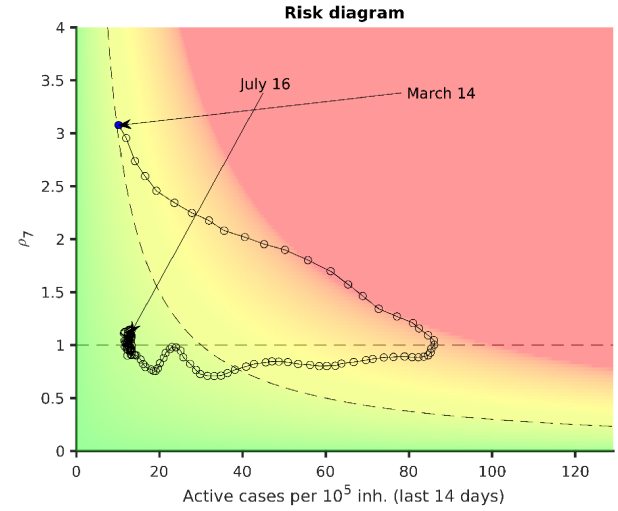


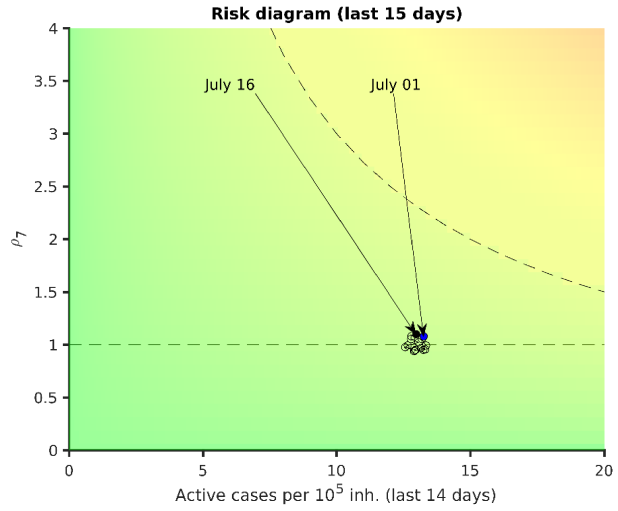




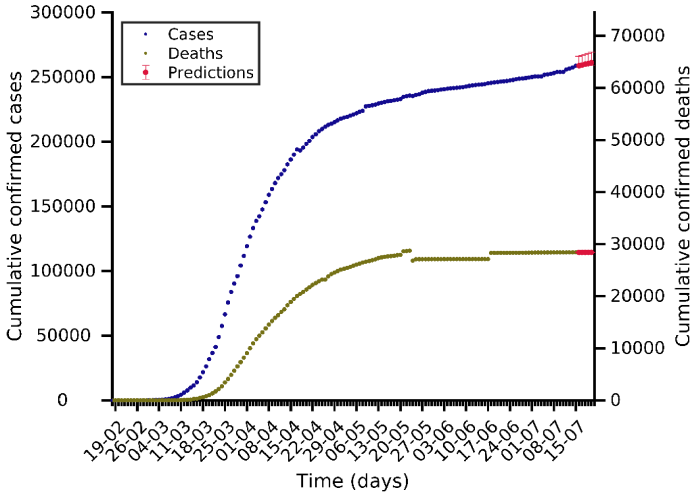


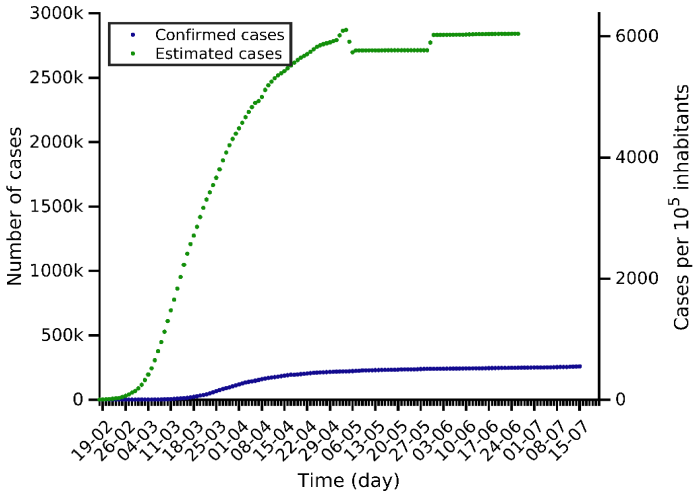


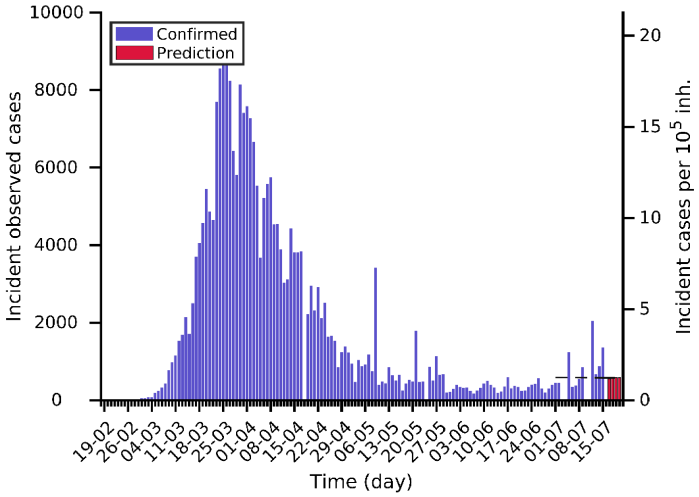


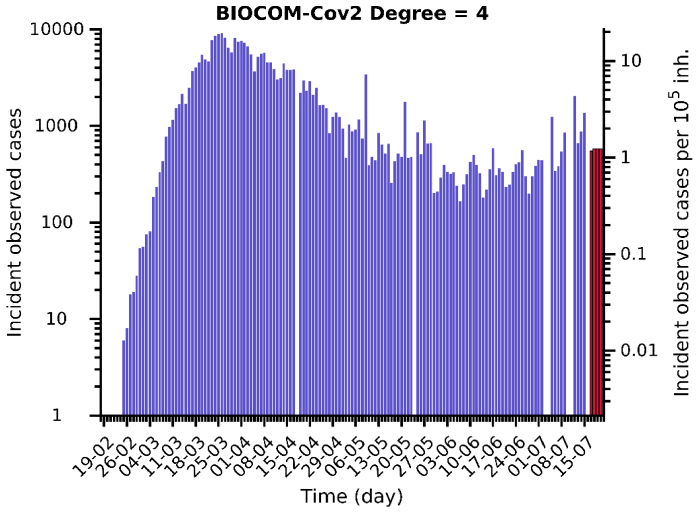


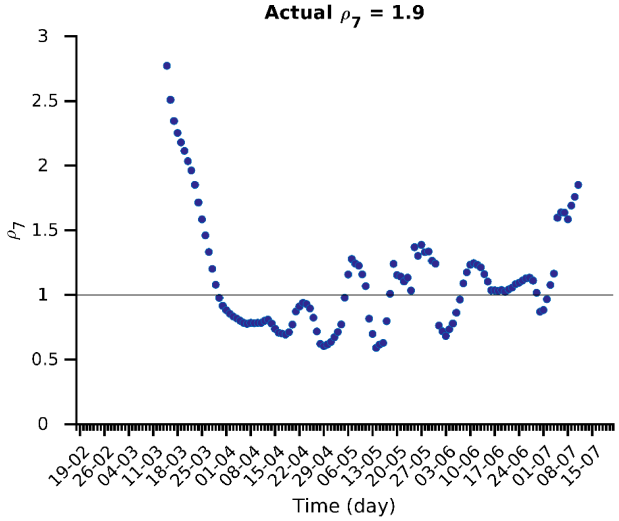
Spain 15-07-2020. Pop: 47.0M. Cumulative incidence: 550/10⁵

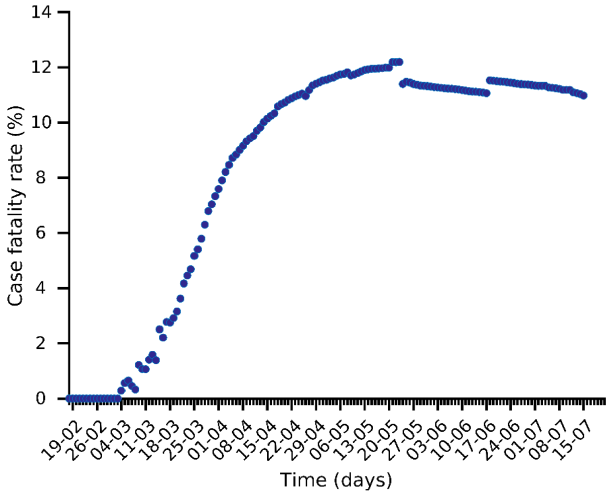


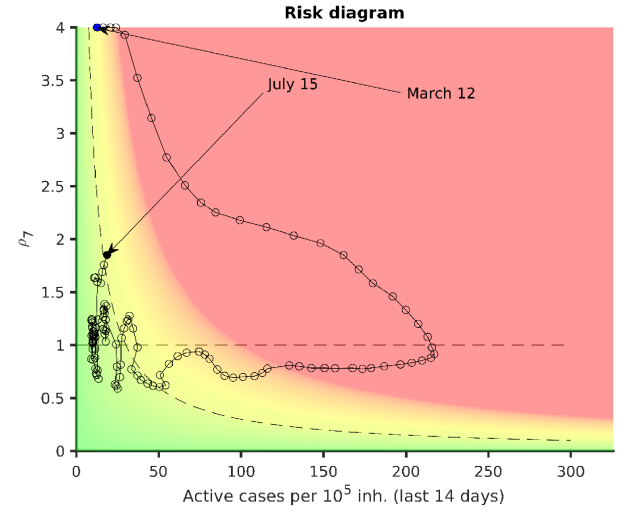


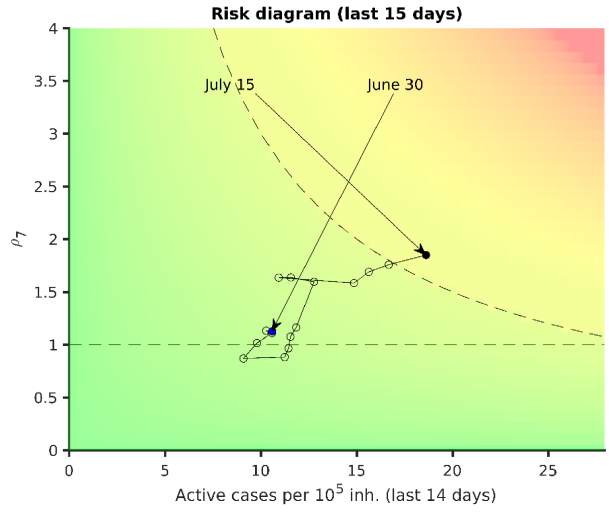




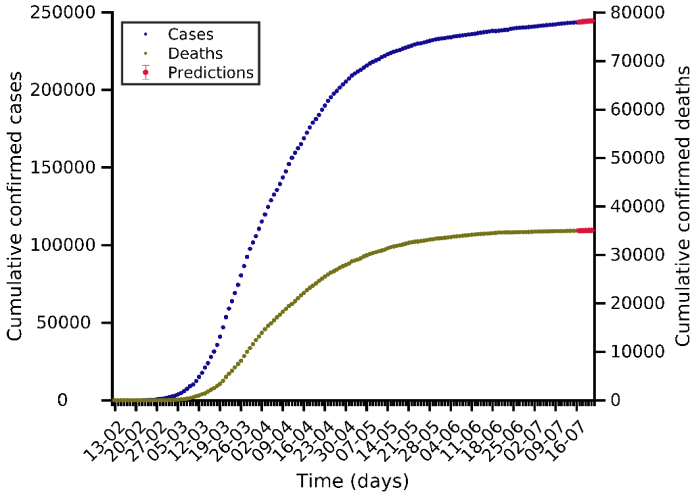


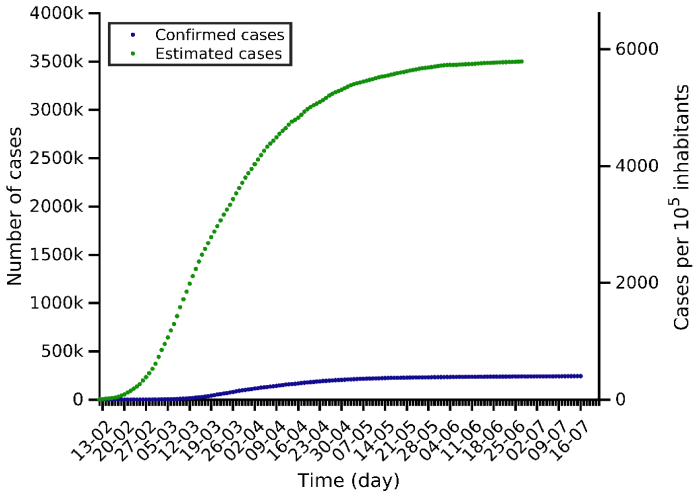


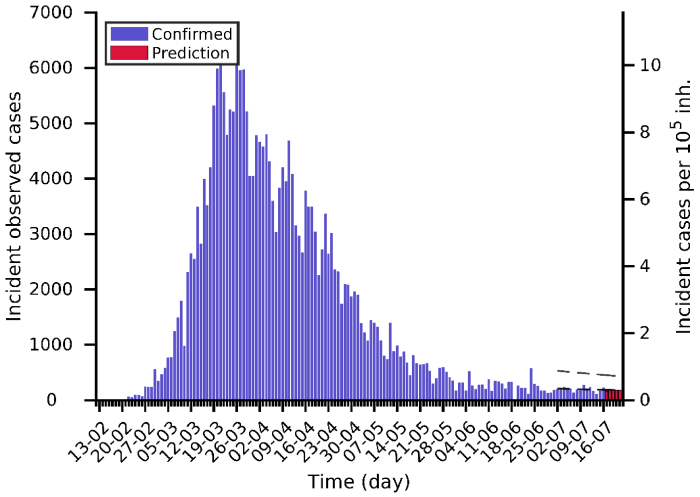


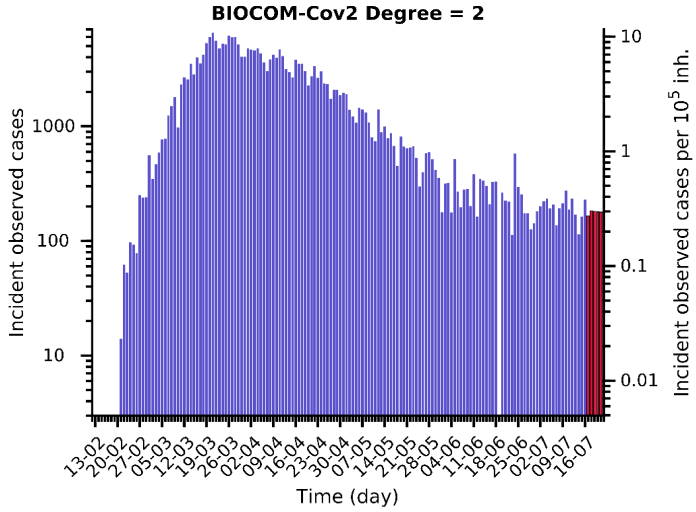


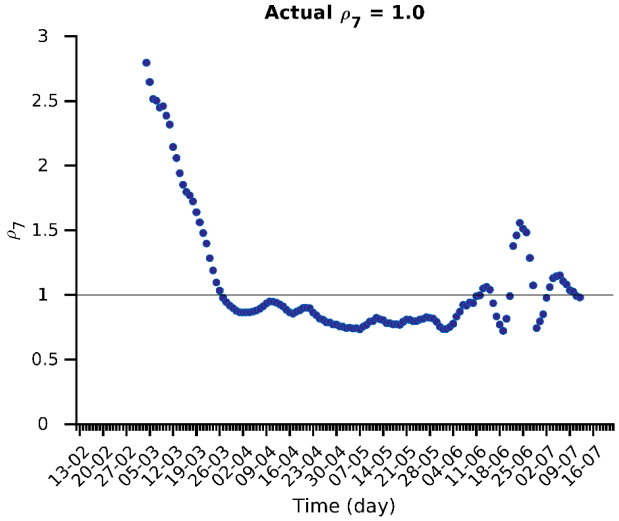
Italy 16-07-2020. Pop: 60.5M. Cumulative incidence: 403/10⁵

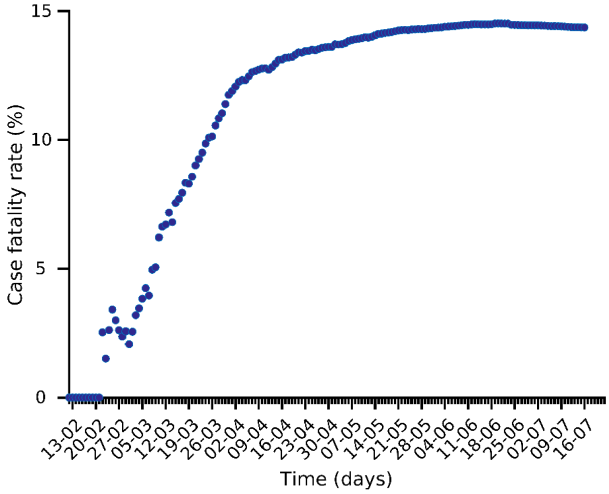


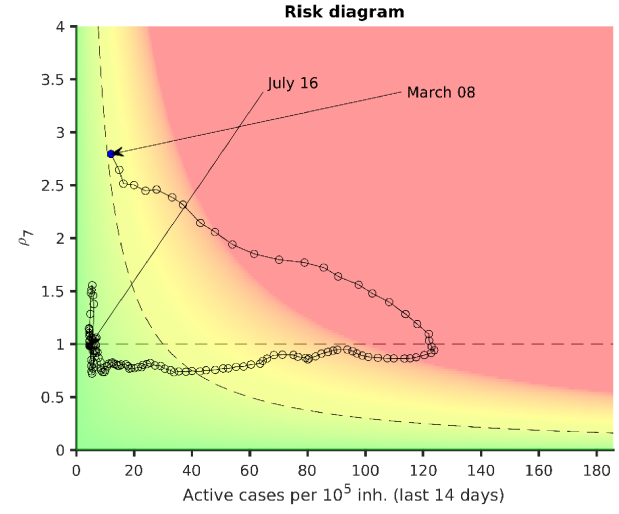


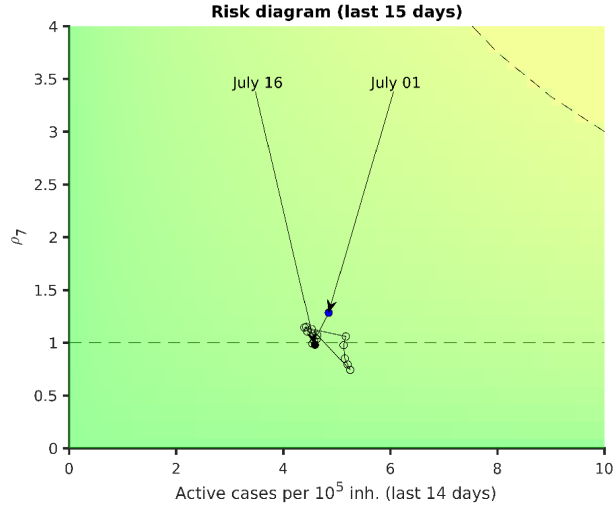




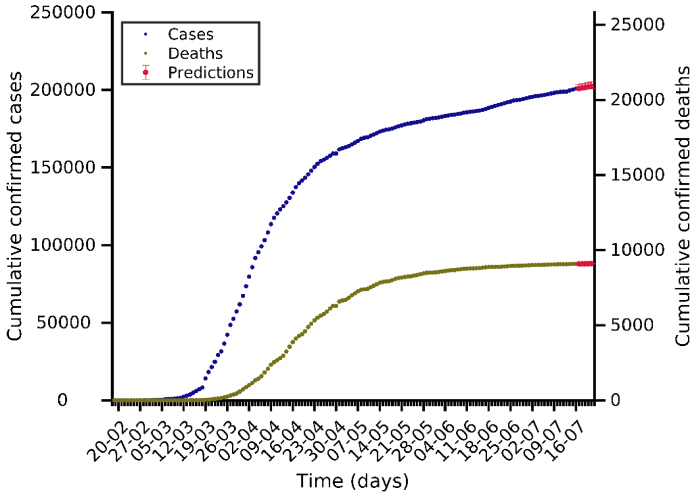


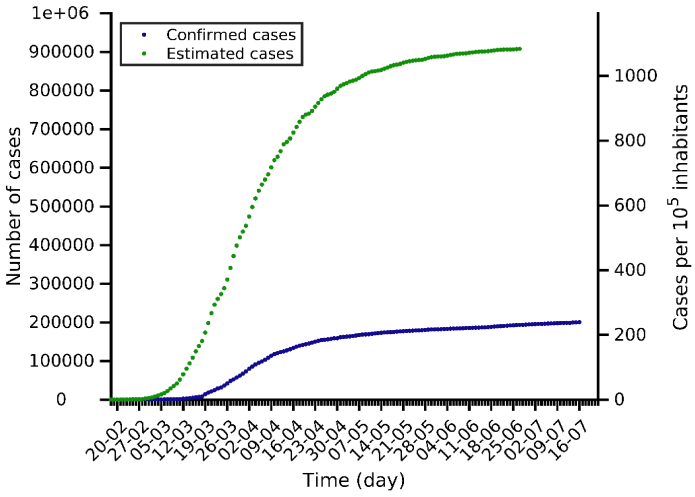


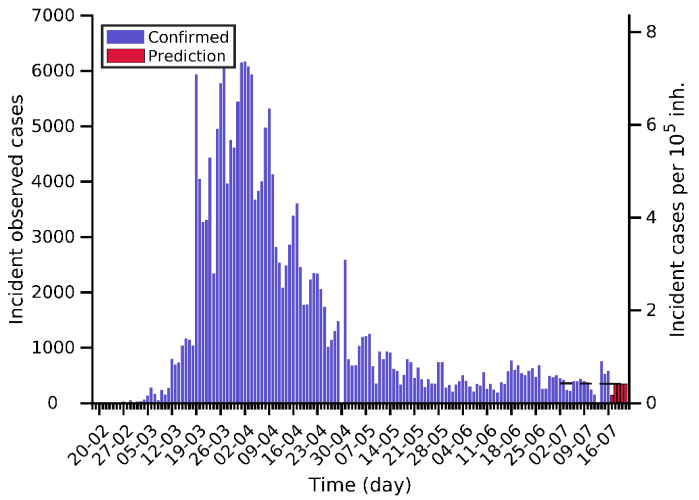


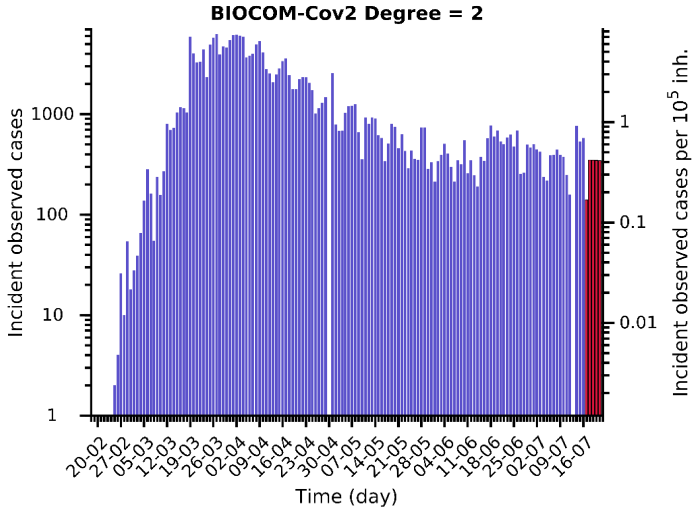


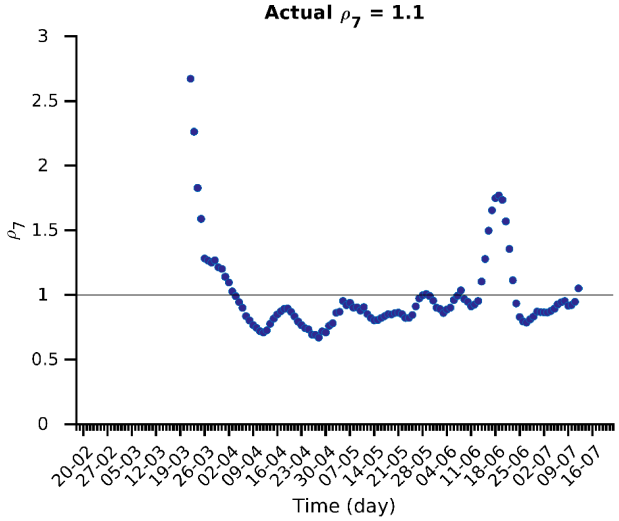
Germany 16-07-2020. Pop: 83.8M. Cumulative incidence: 240/10⁵

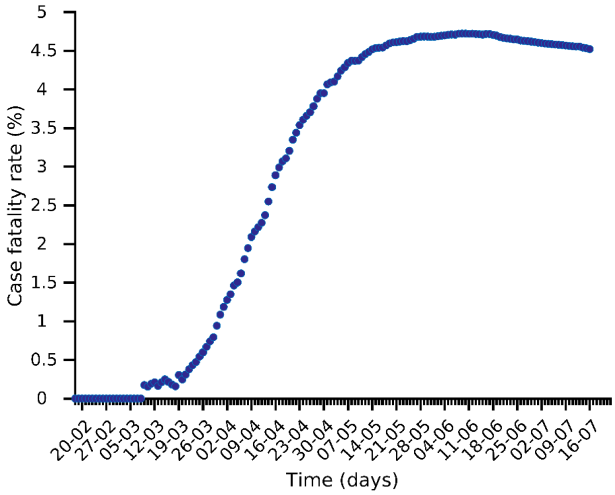


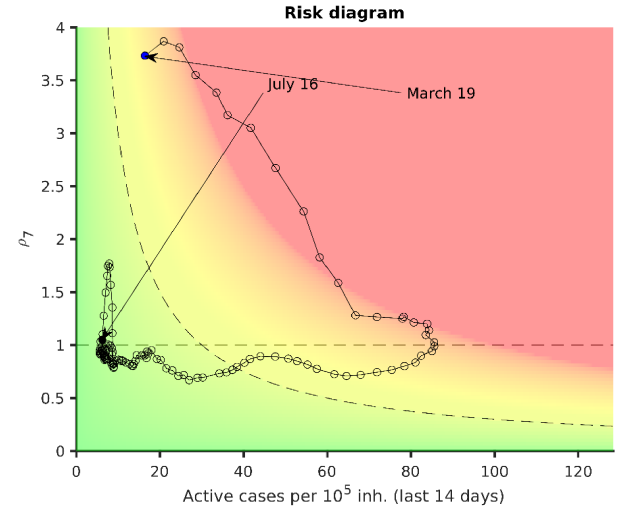


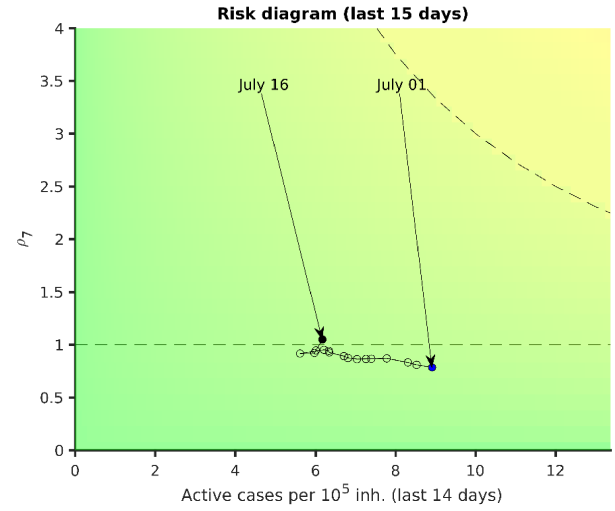




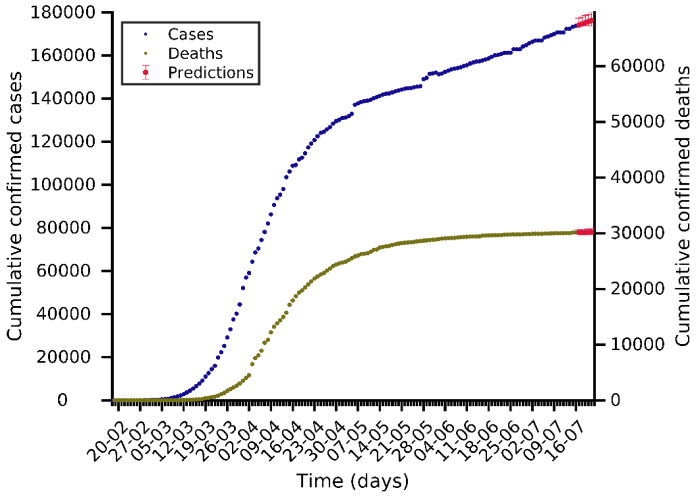


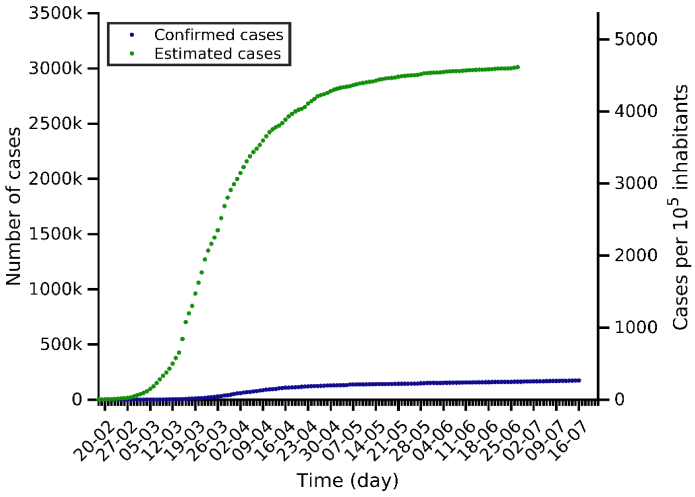


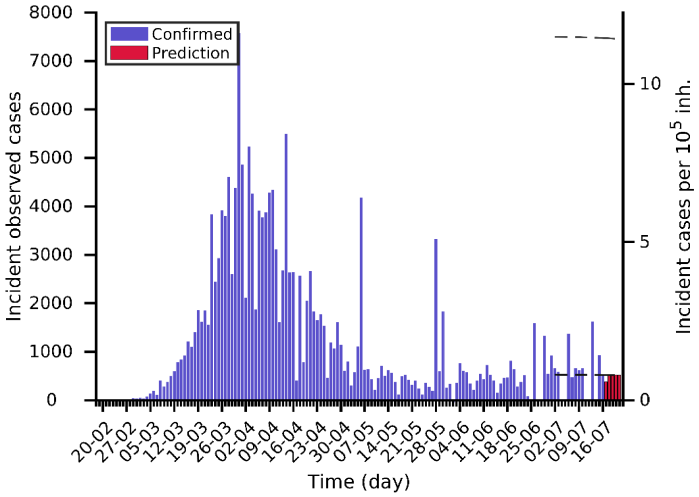


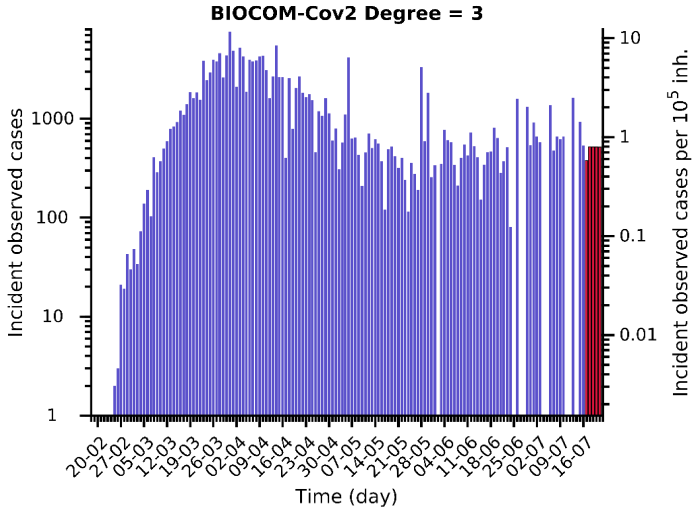


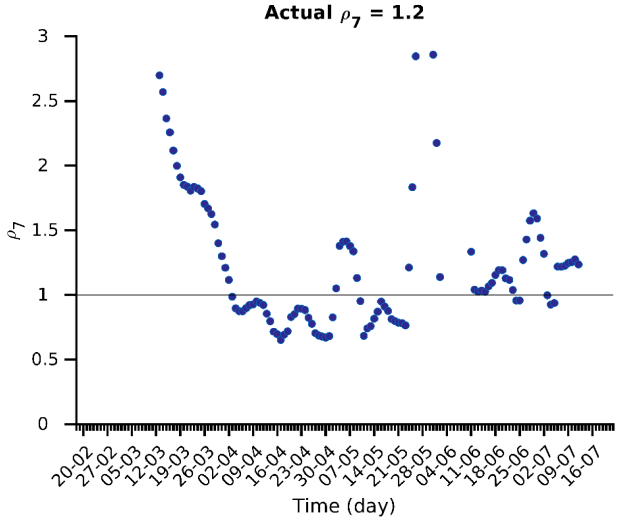
France 16-07-2020. Pop: 65.3M. Cumulative incidence: 266/10⁵

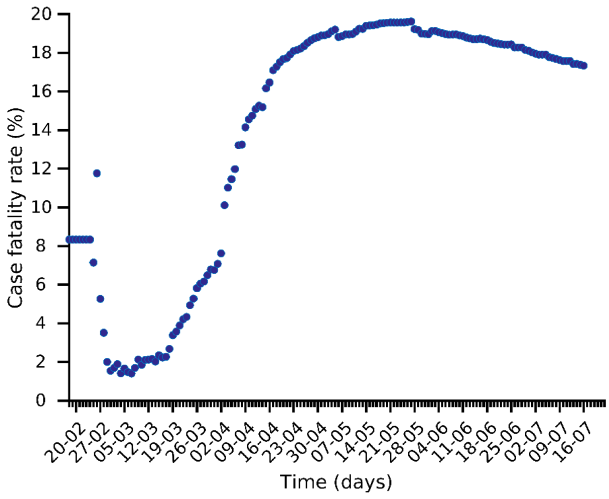


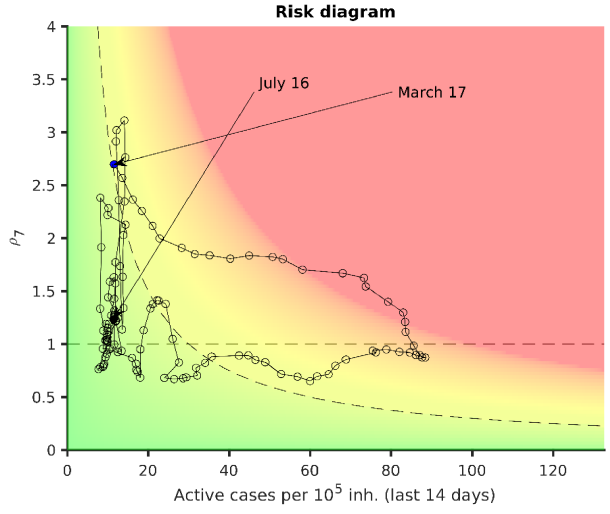


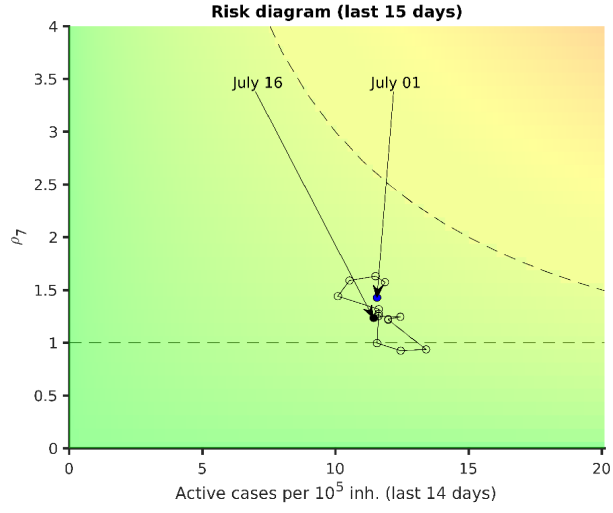




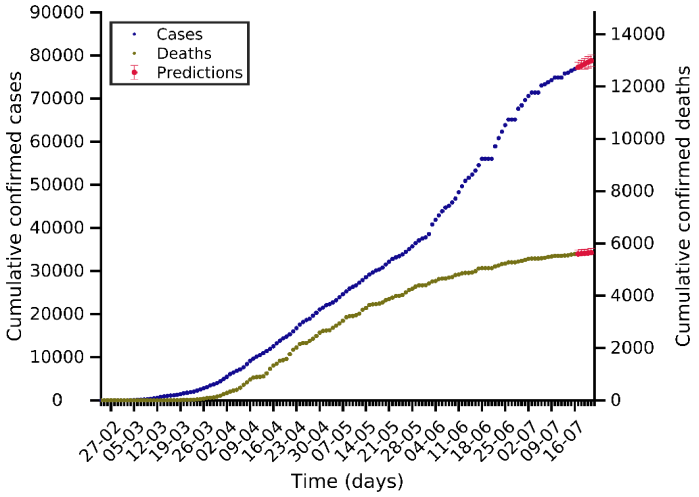


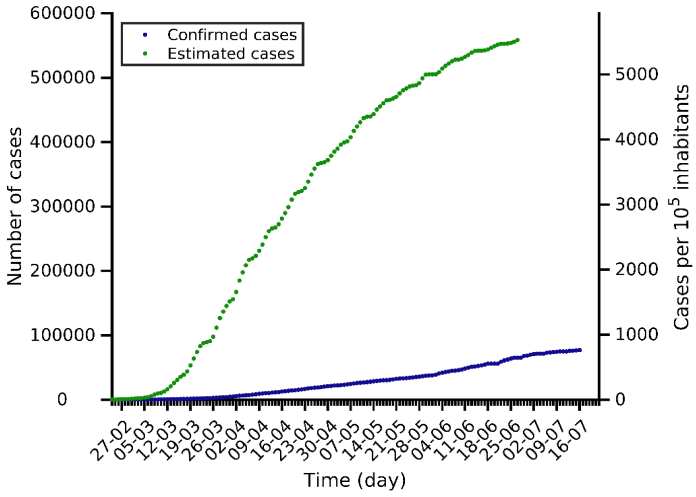


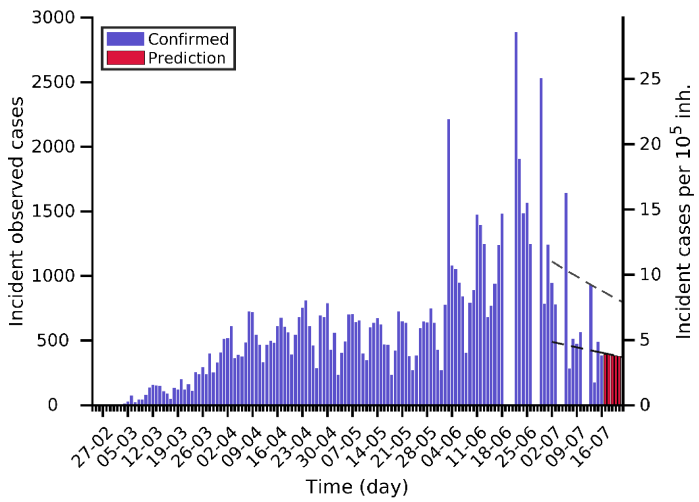


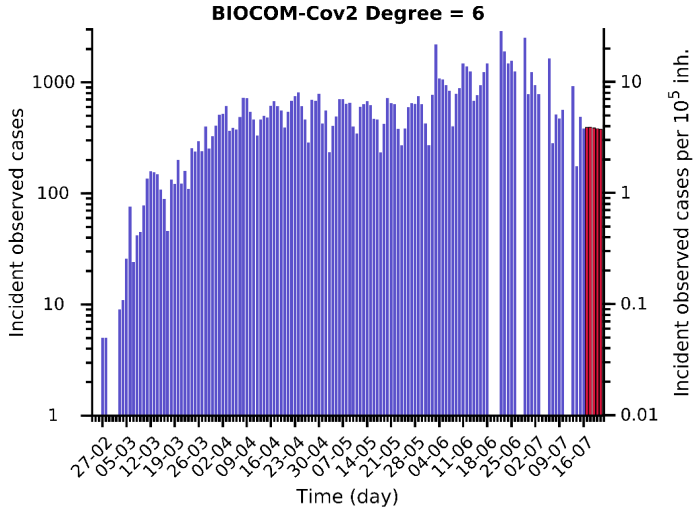


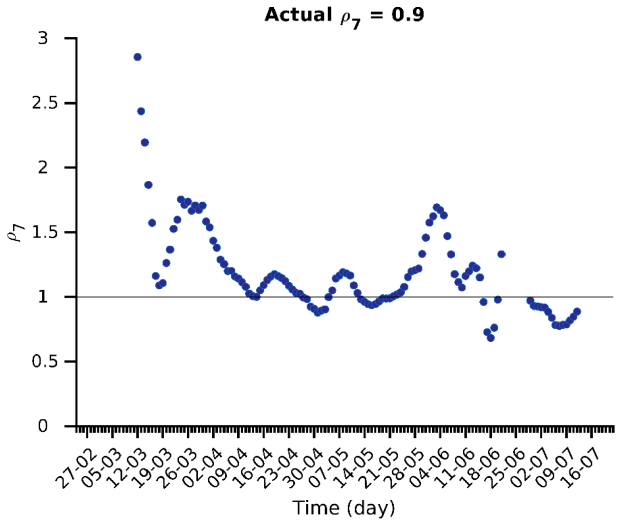
Sweden 16-07-2020. Pop: 10.1M. Cumulative incidence: 761/10⁵

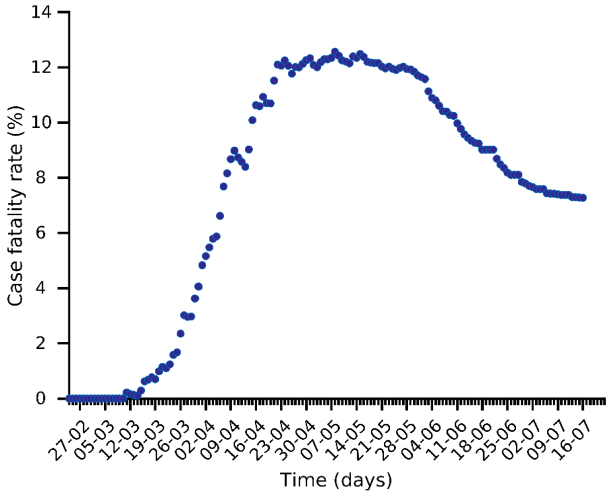


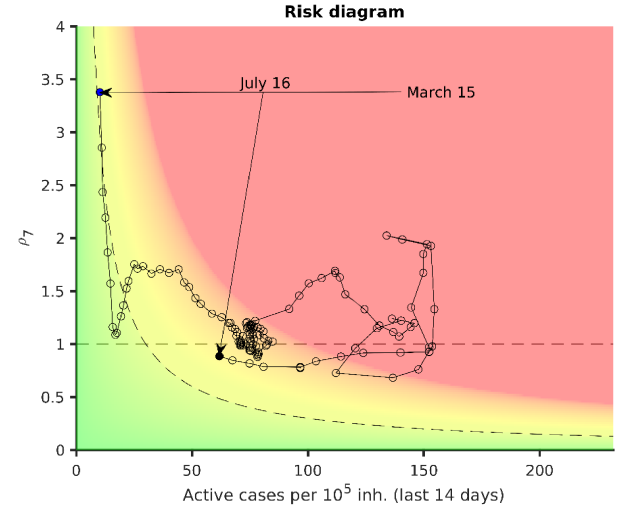


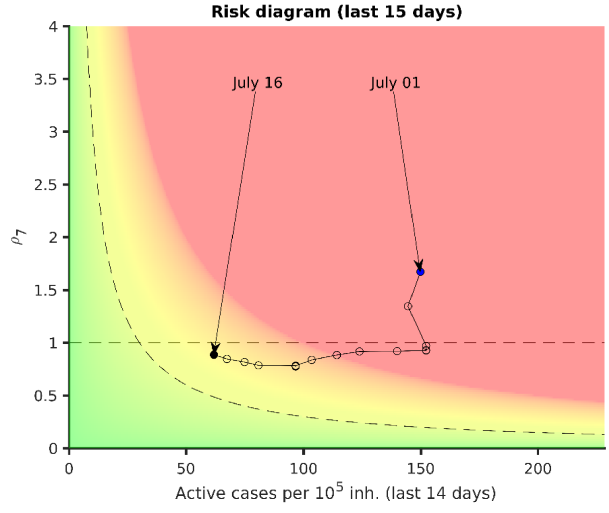




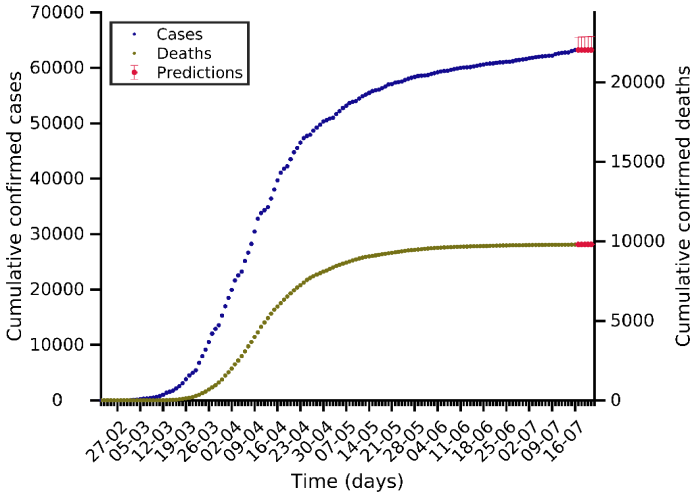


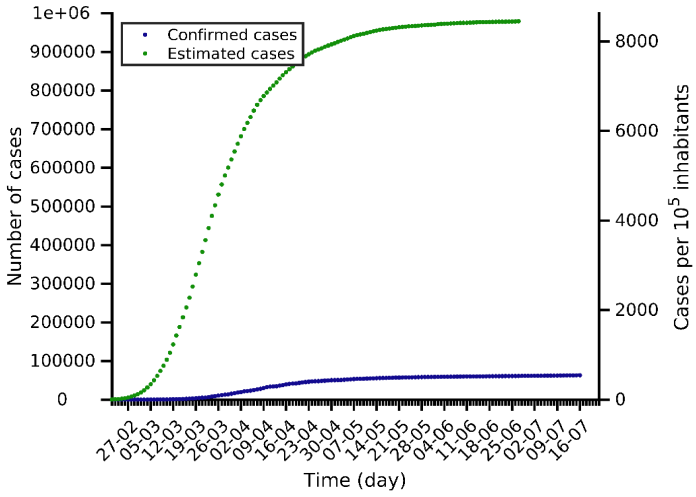


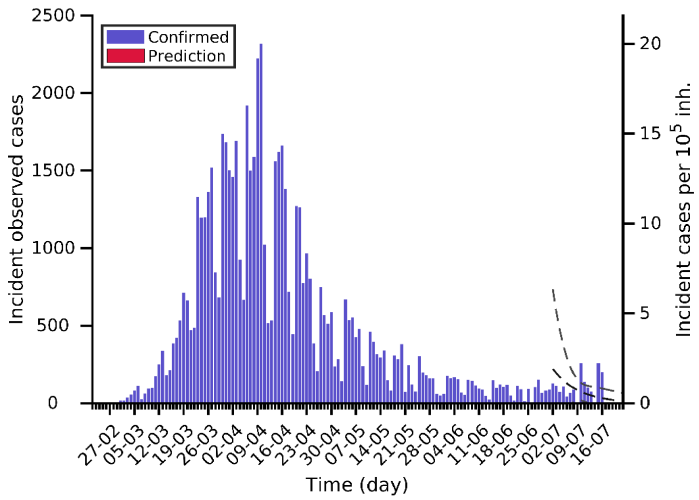


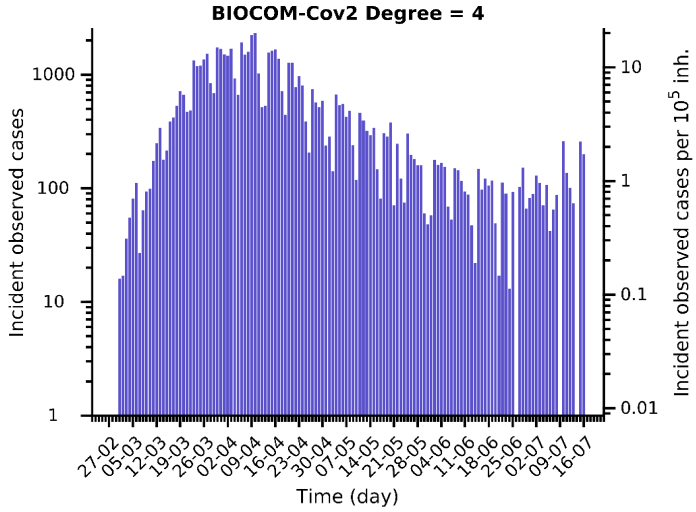


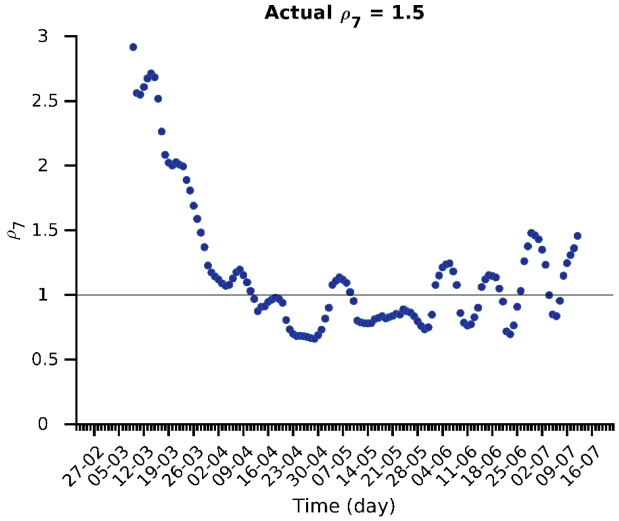
Belgium 16-07-2020. Pop: 11.6M. Cumulative incidence: 546/10^5

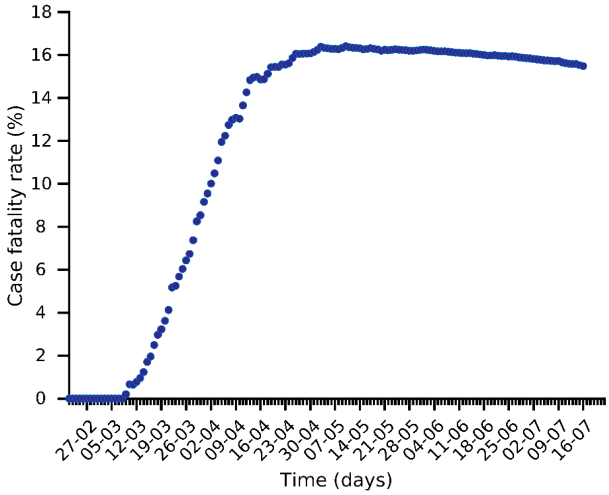


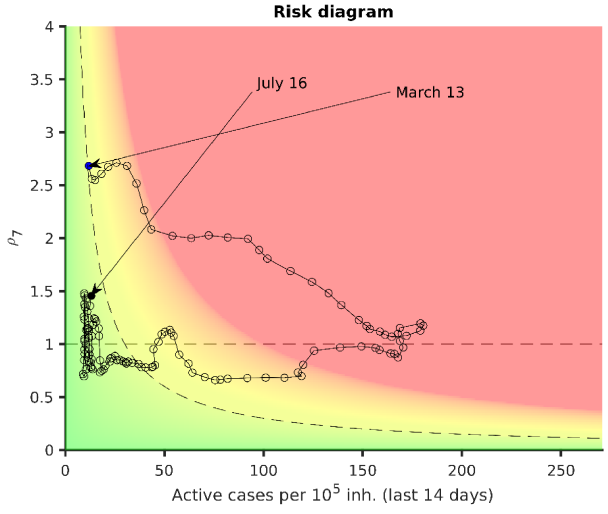


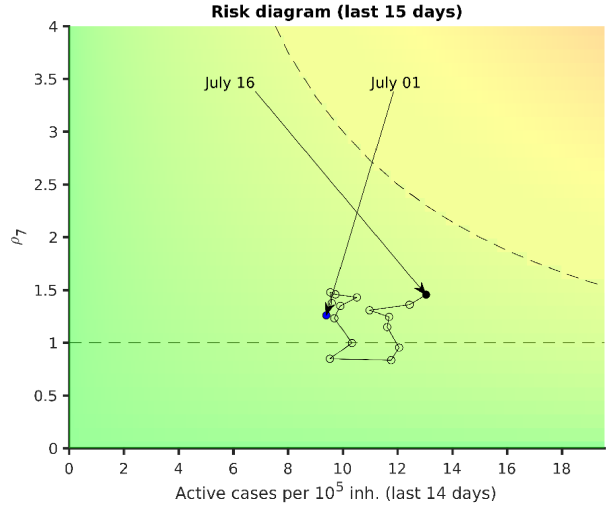




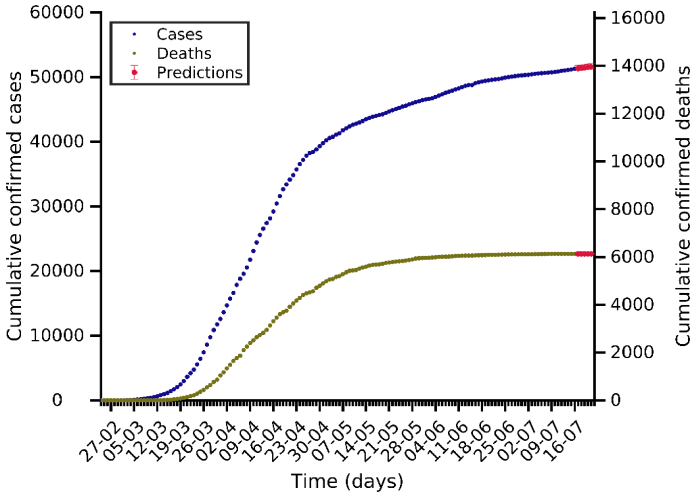


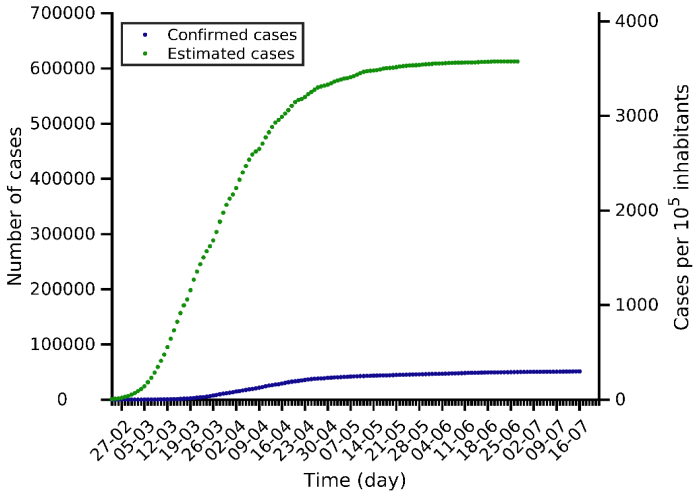


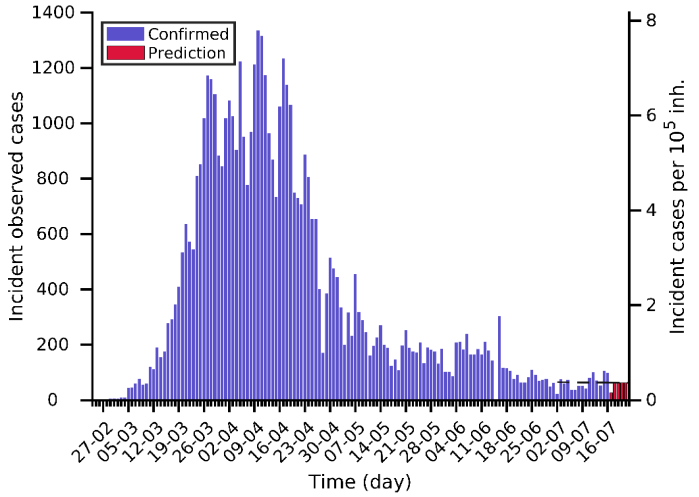


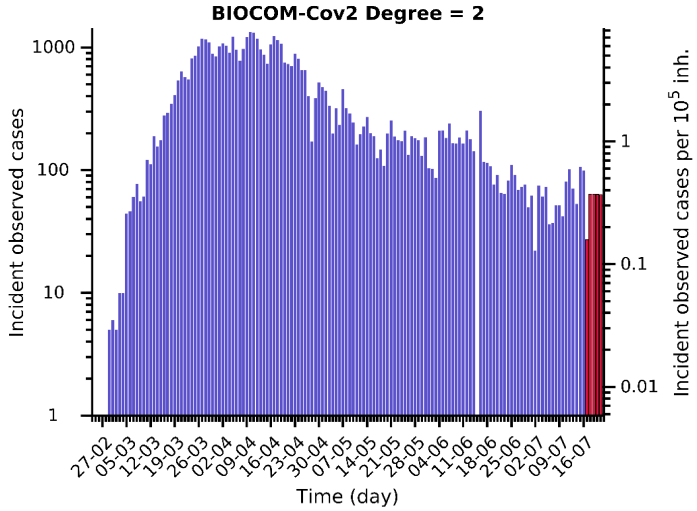


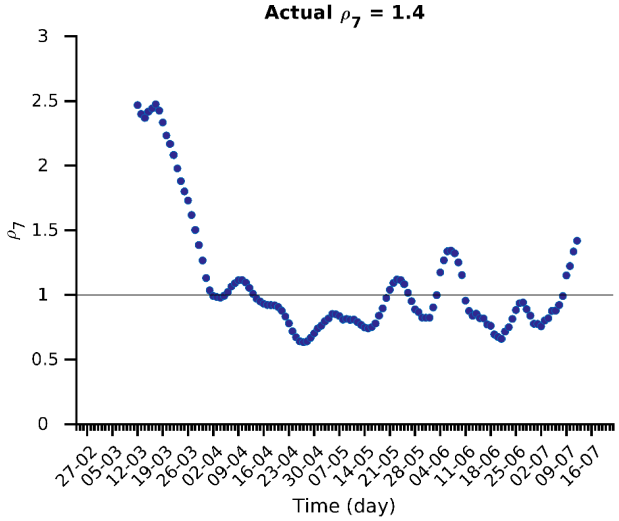
Netherlands 16-07-2020. Pop: 17.1M. Cumulative incidence: 299/10⁵

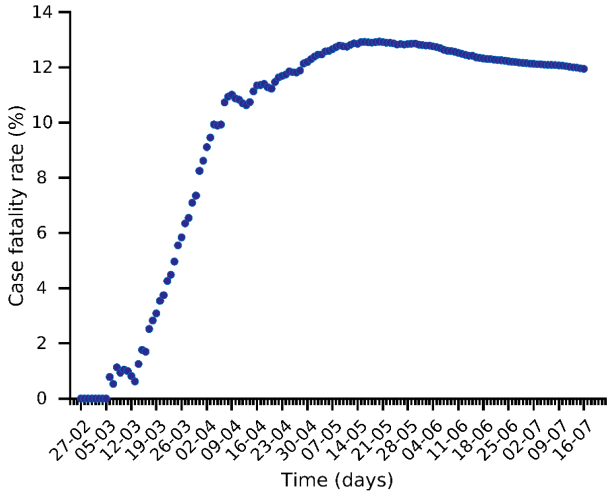


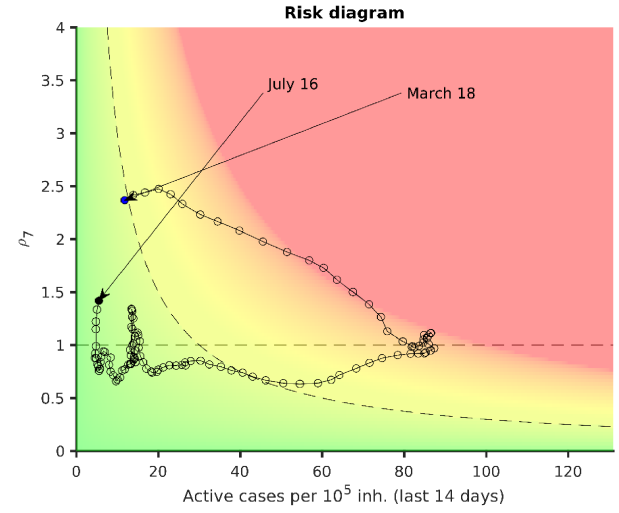


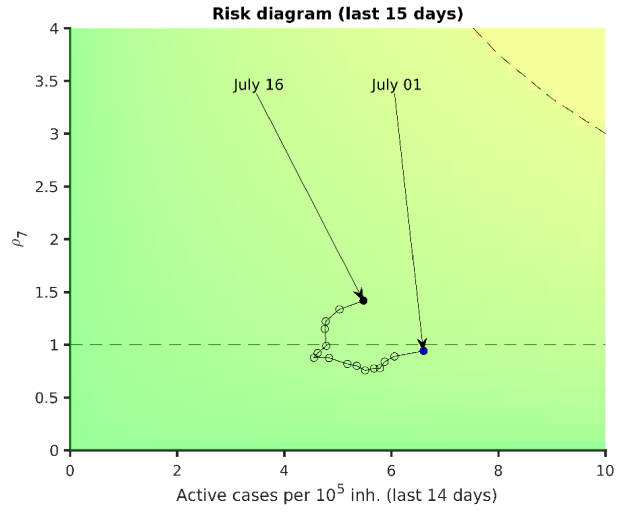




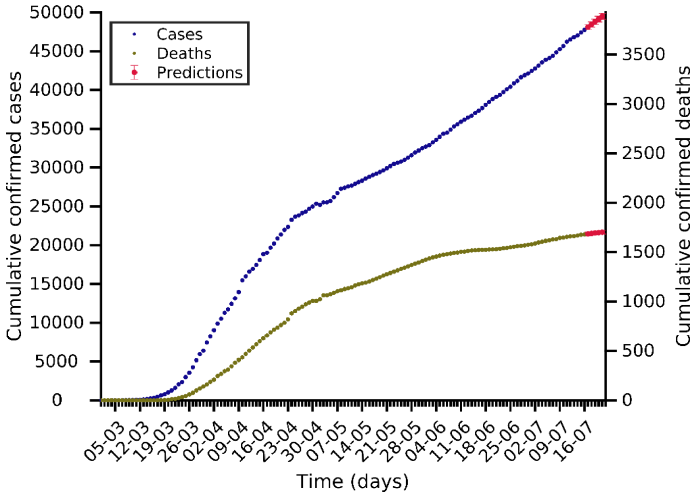


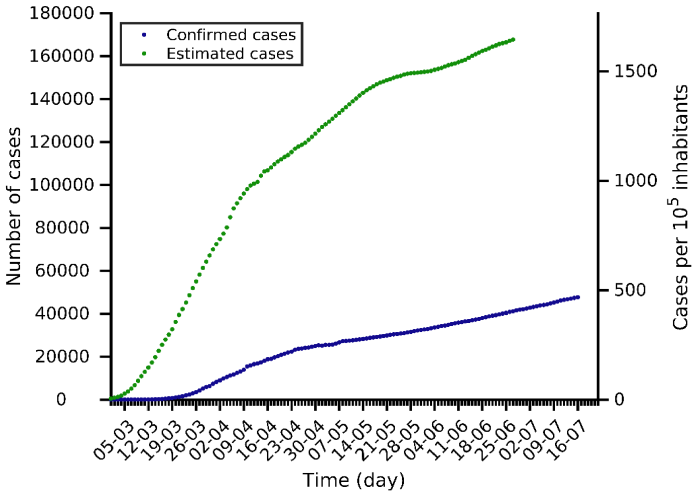


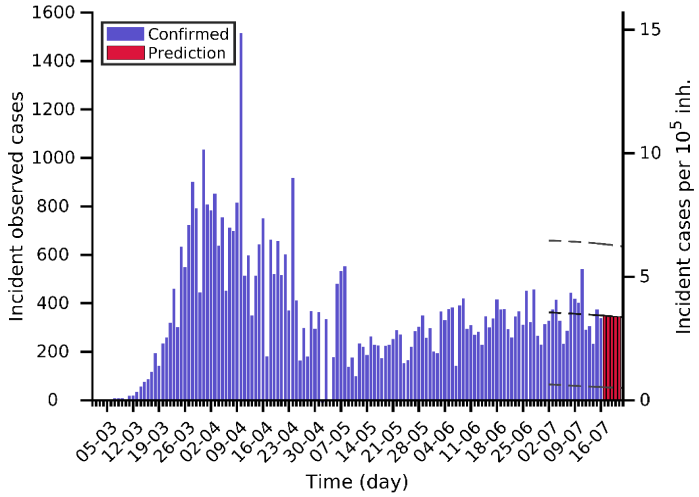


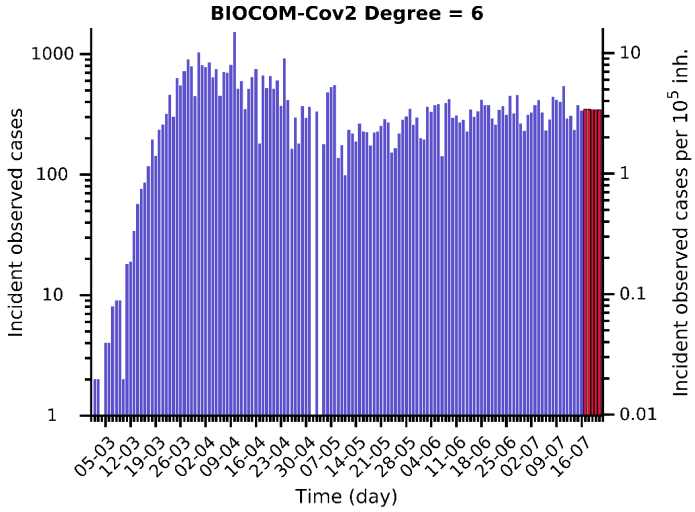


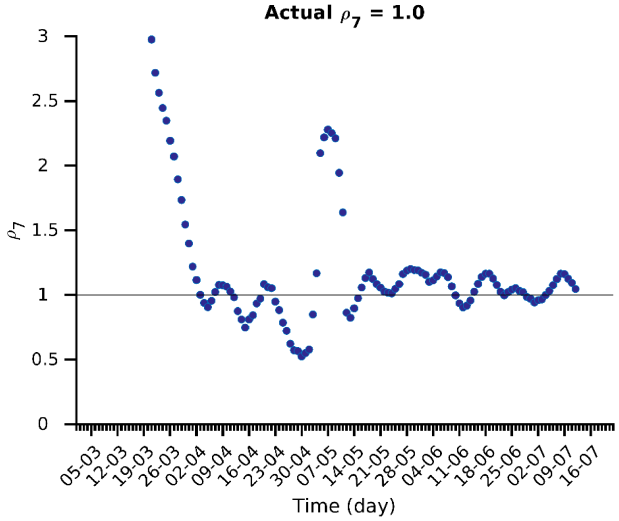
Portugal 16-07-2020. Pop: 10.2M. Cumulative incidence: 468/10⁵

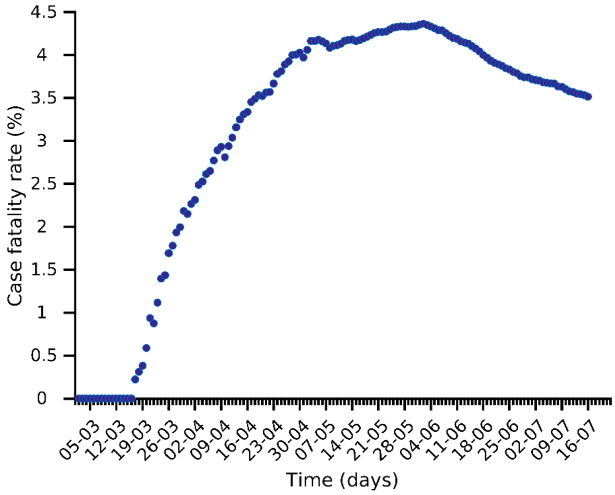


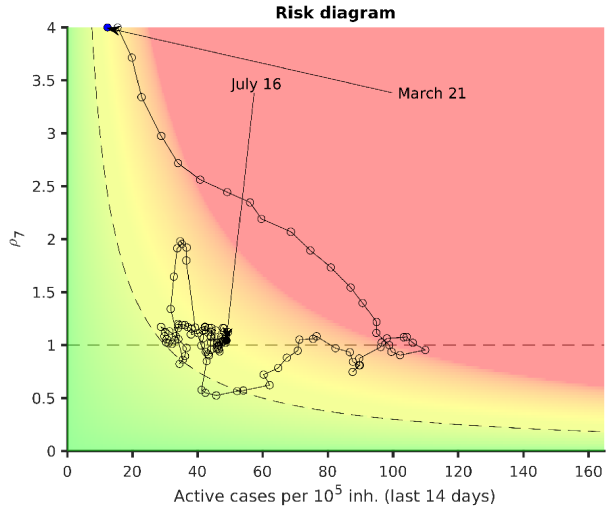


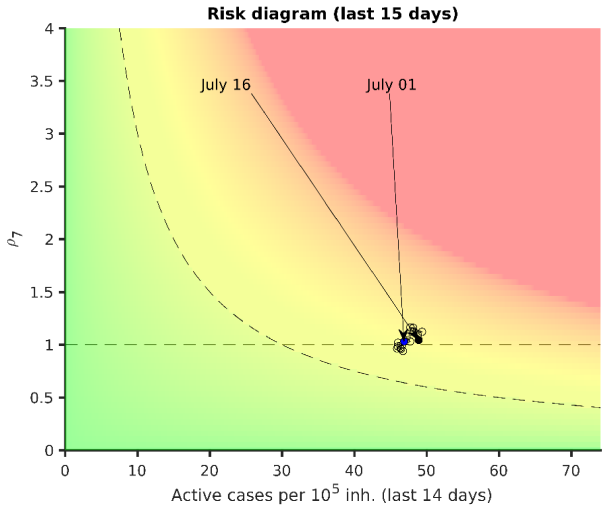




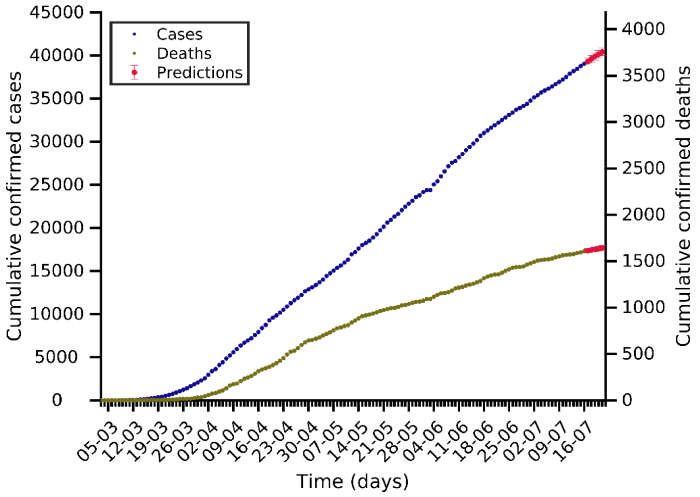


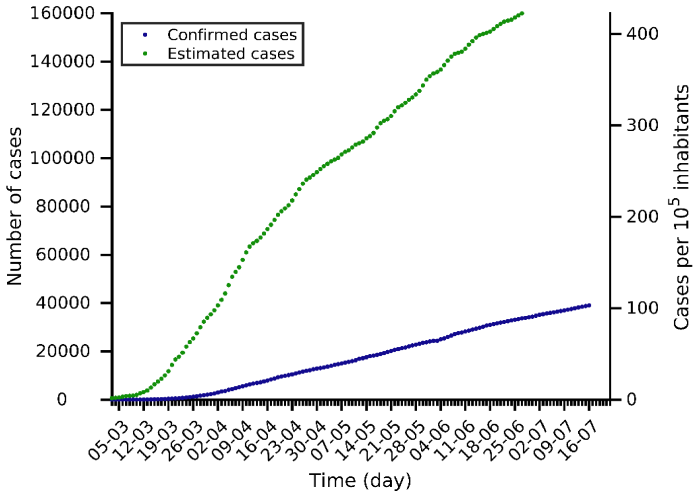


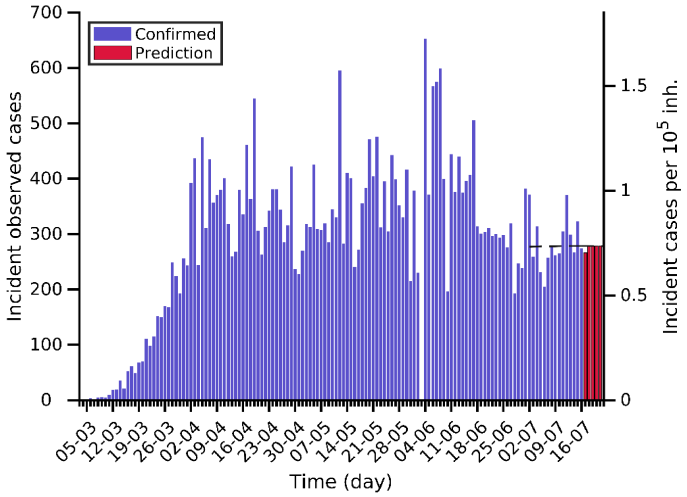


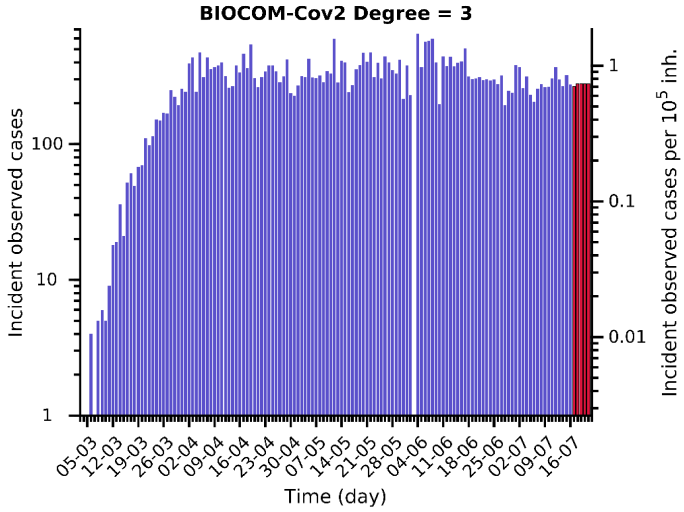


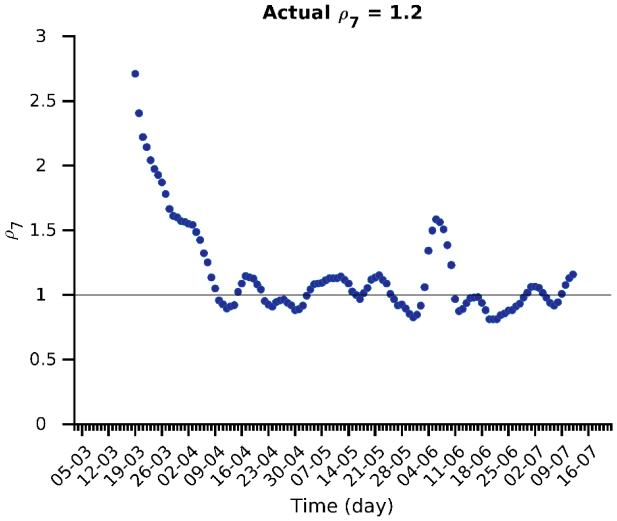
Poland 16-07-2020. Pop: 37.8M. Cumulative incidence: 103/10⁵

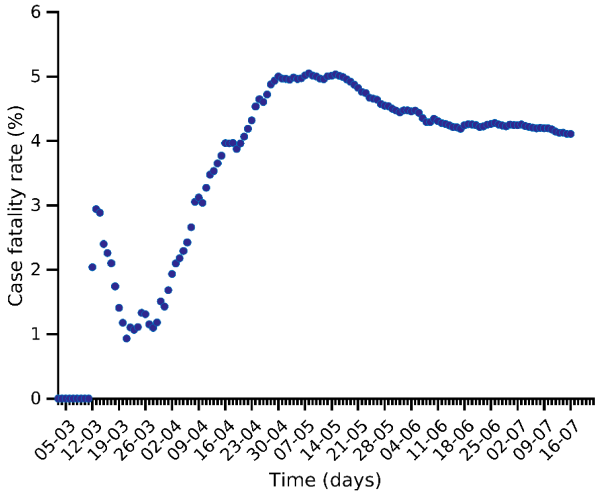


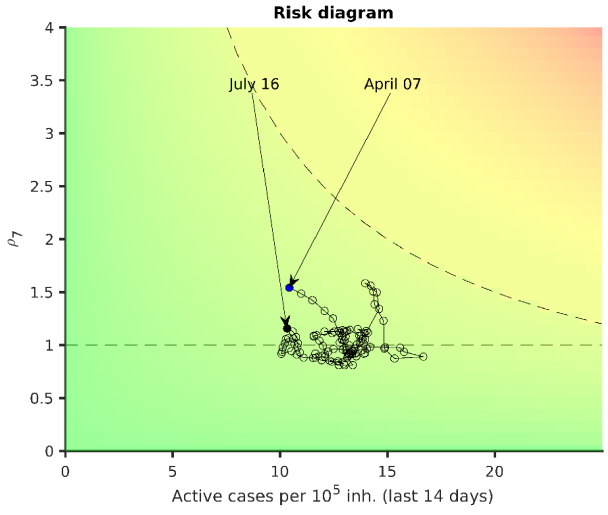


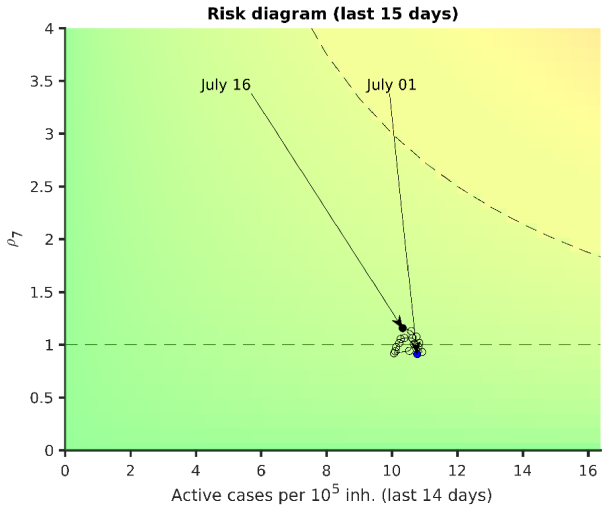




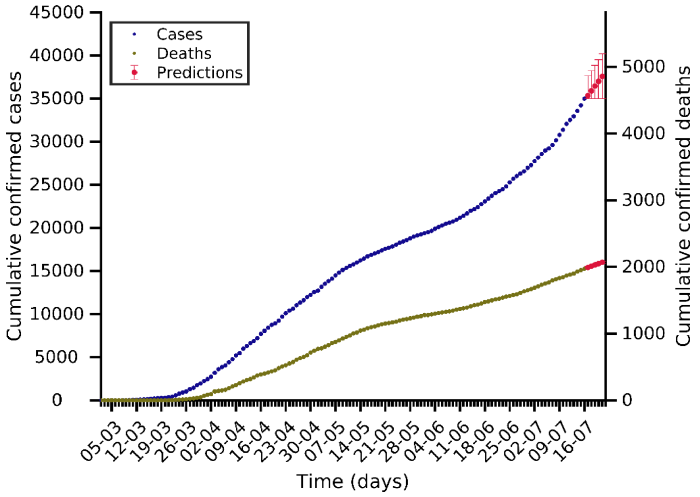


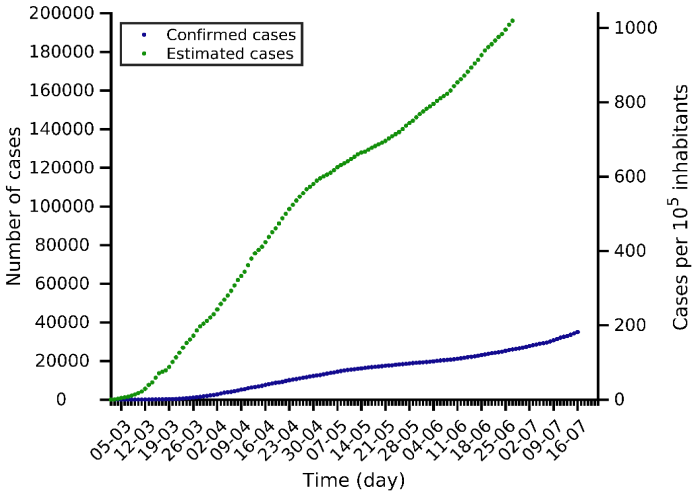


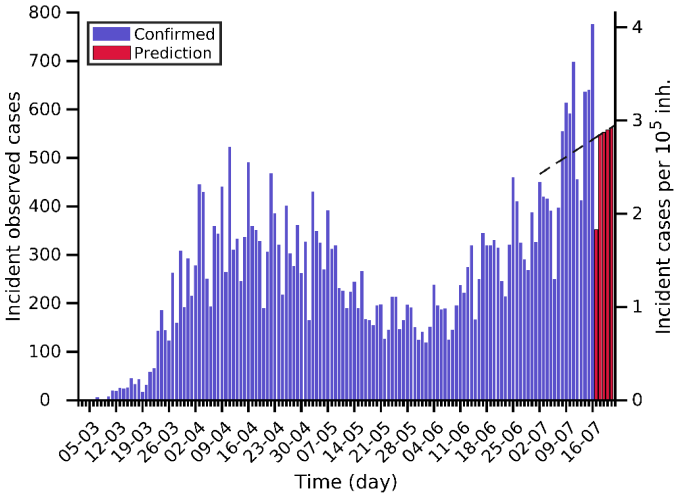


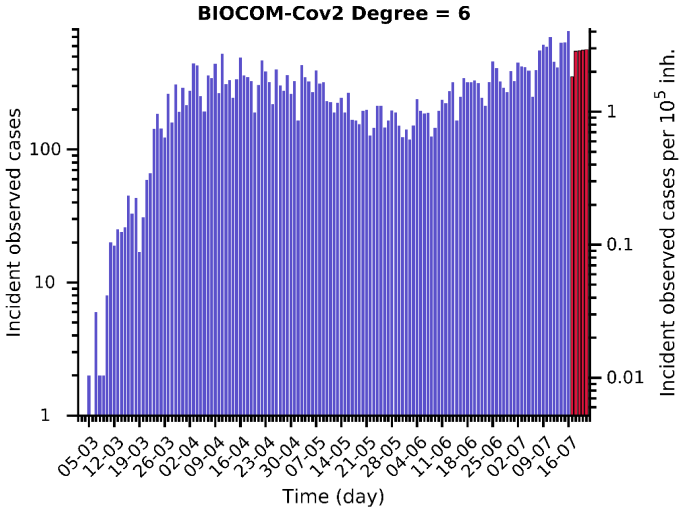


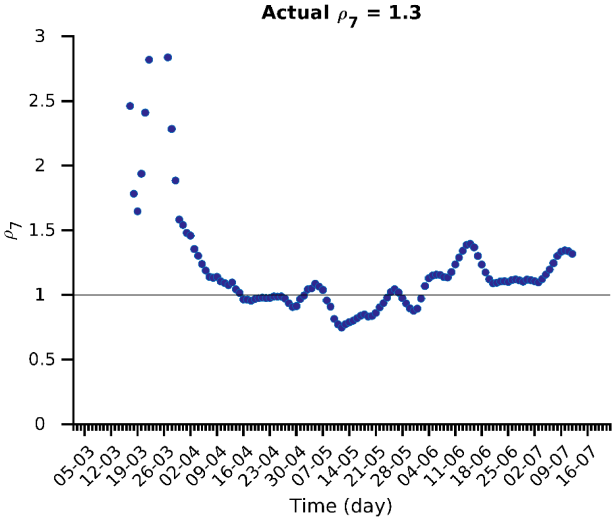
Romania 16-07-2020. Pop: 19.2M. Cumulative incidence: 182/10^5

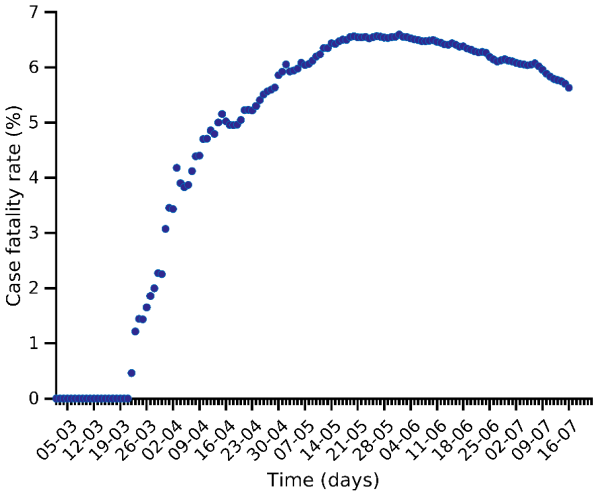


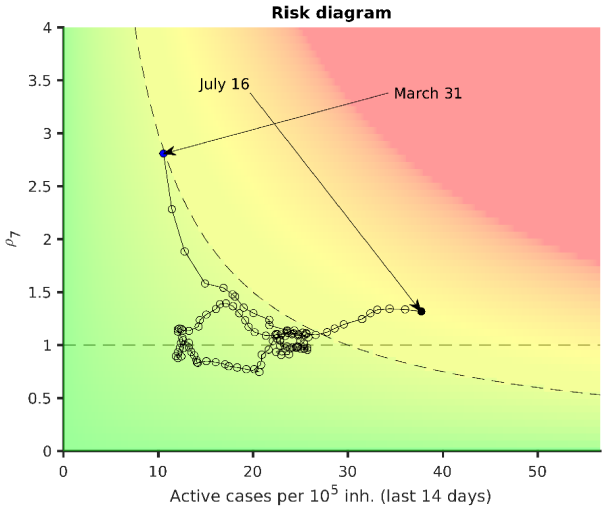


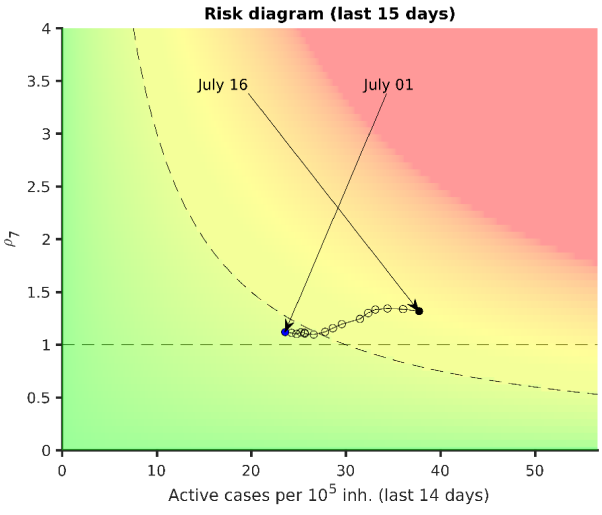




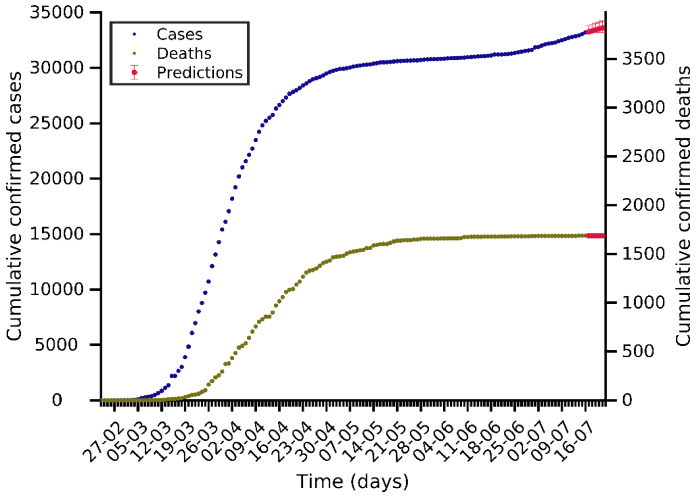


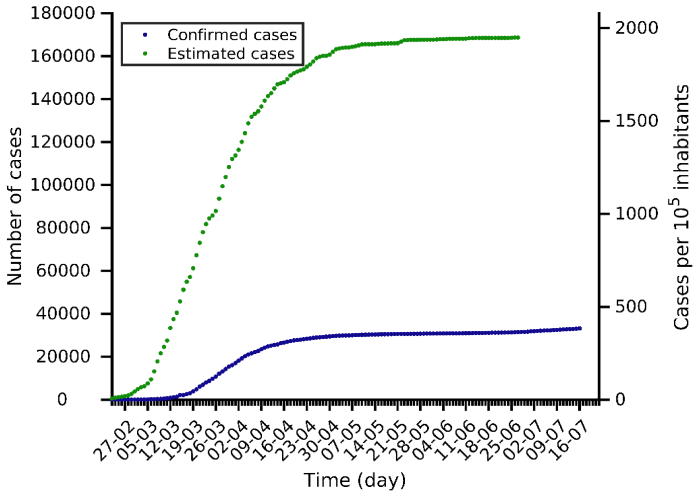


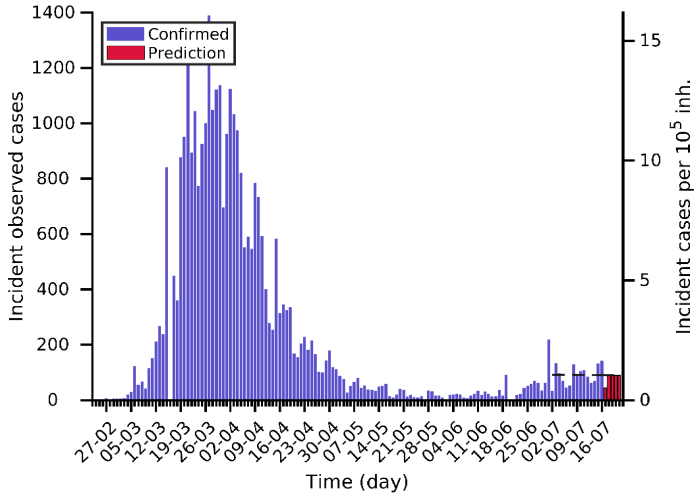


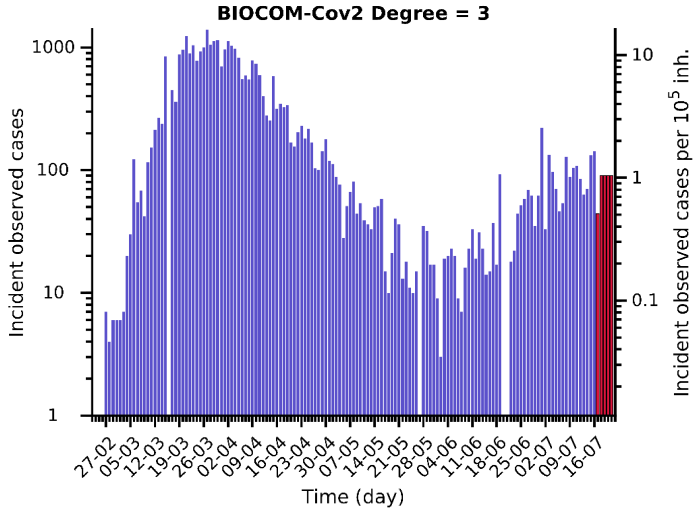


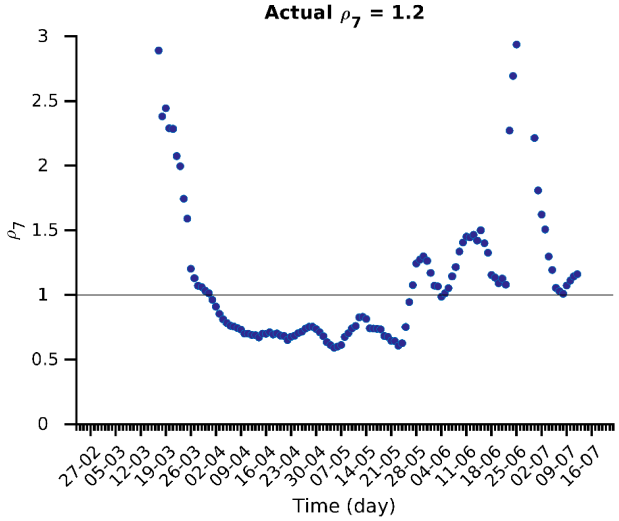
Switzerland 16-07-2020. Pop: 8.7M. Cumulative incidence: 384/10⁵

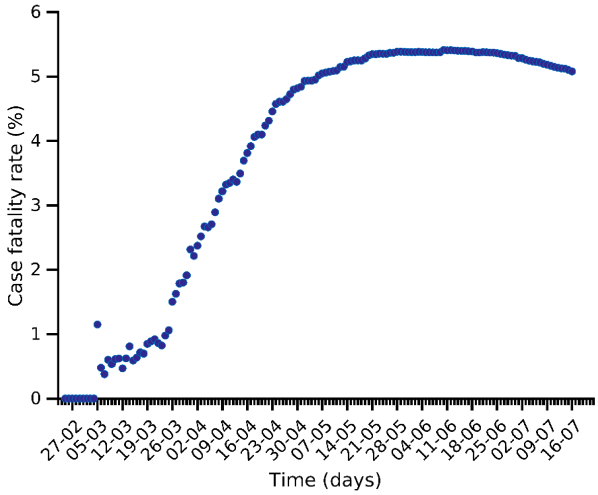


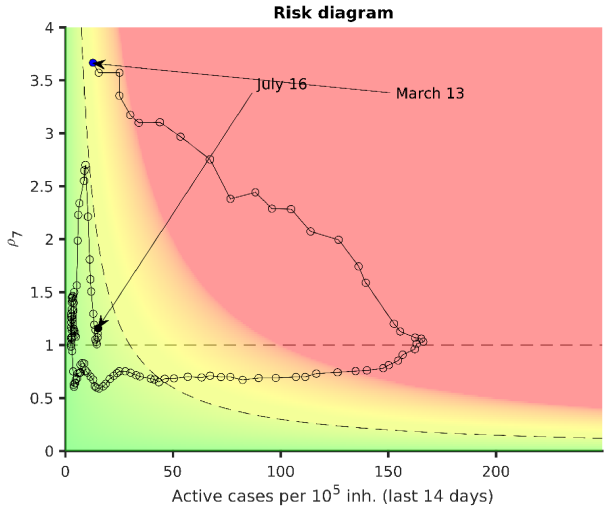


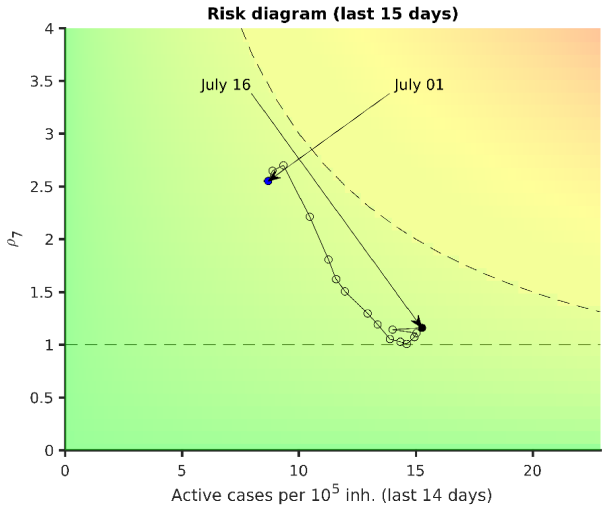




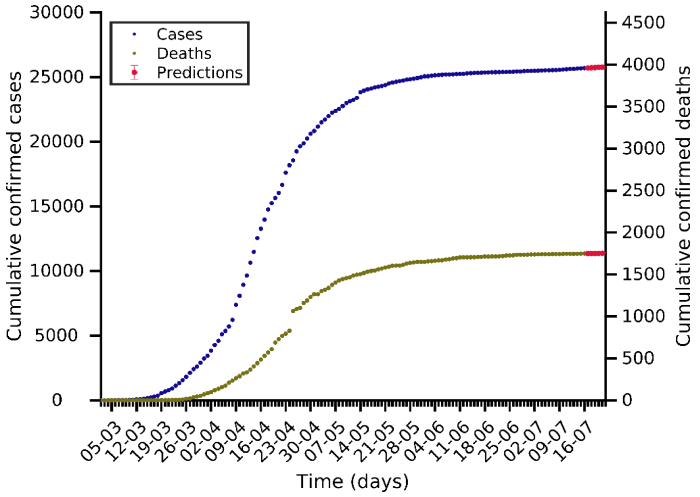


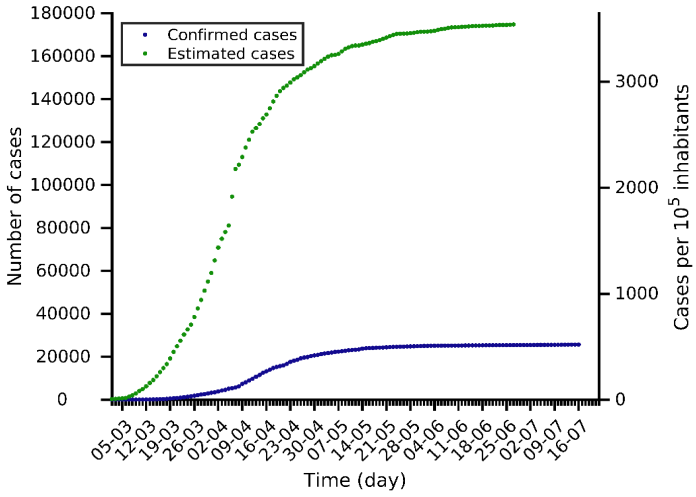


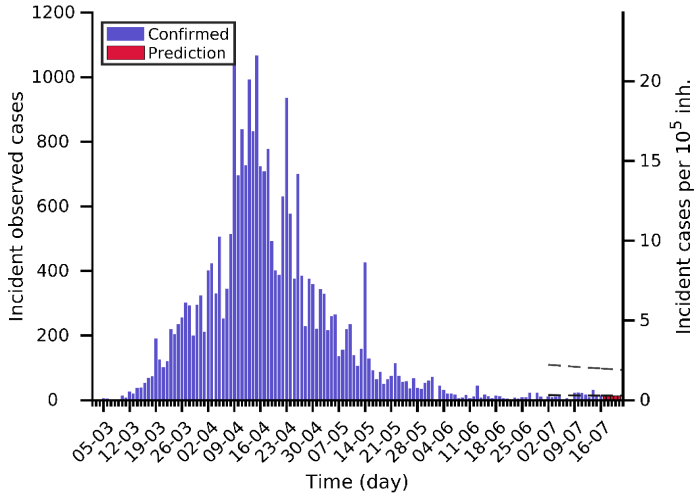


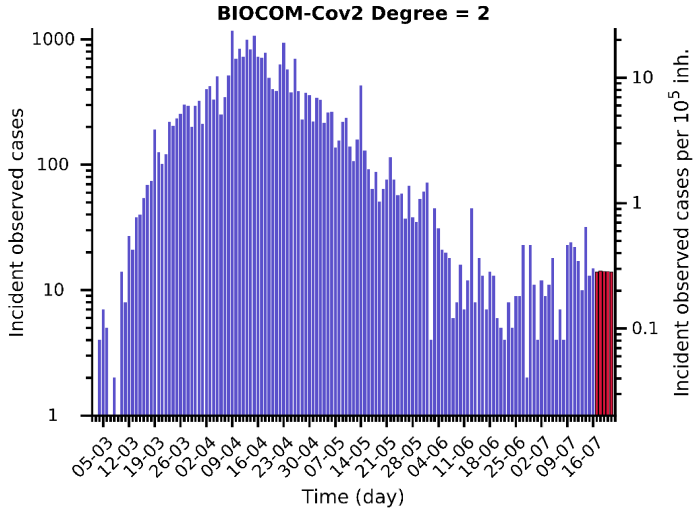


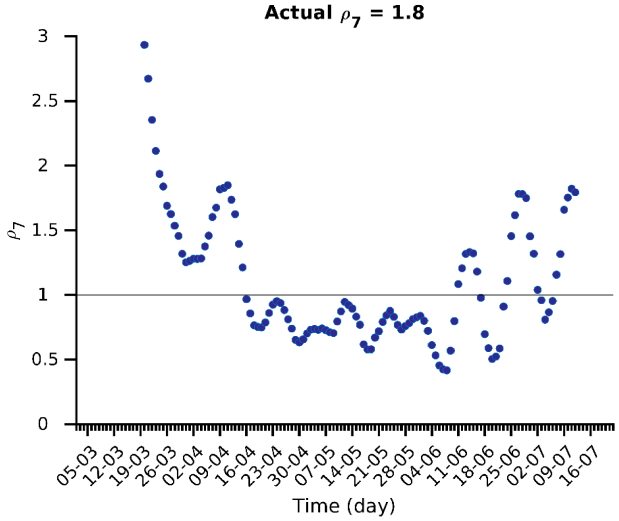
Ireland 16-07-2020. Pop: 4.9M. Cumulative incidence: 520/10⁵

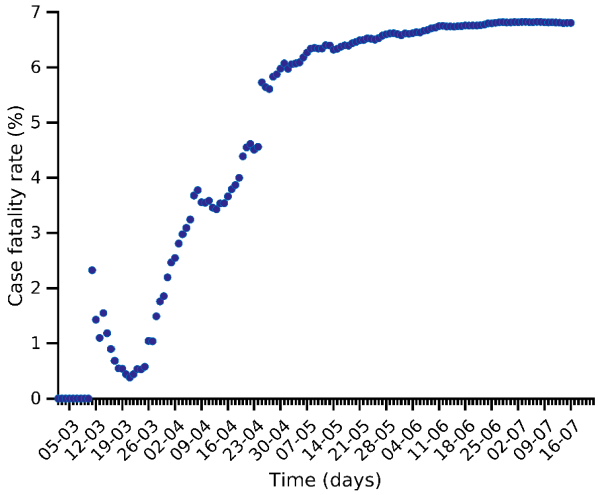


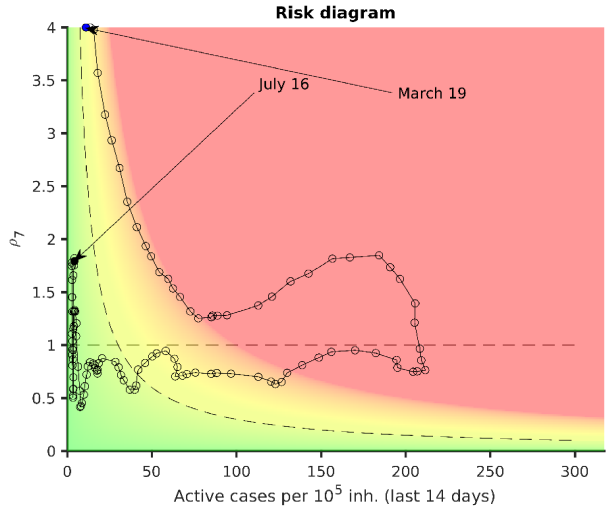


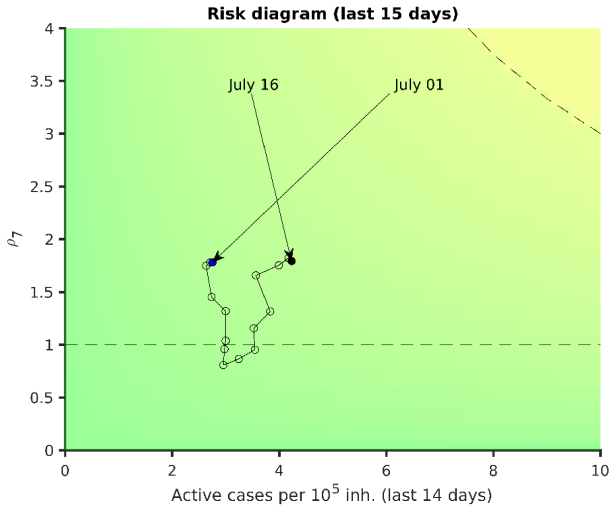




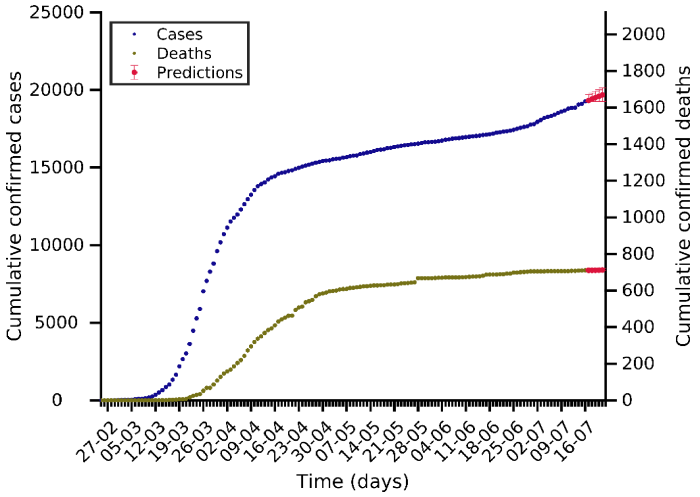


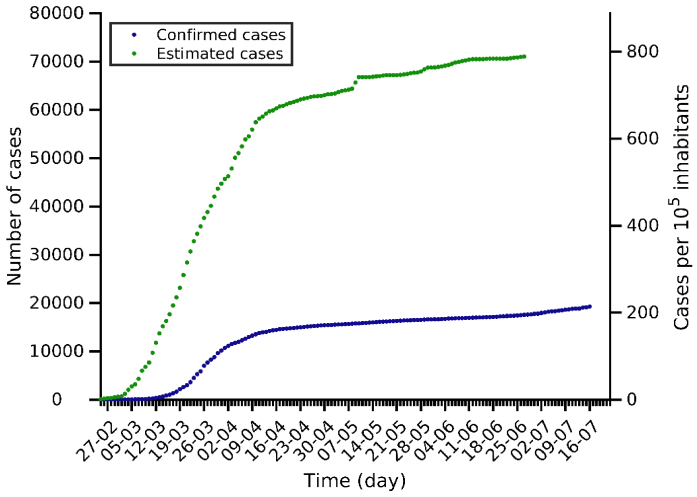


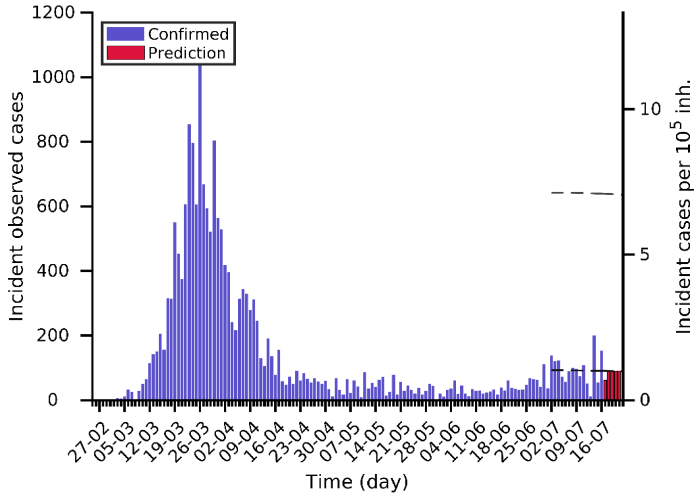


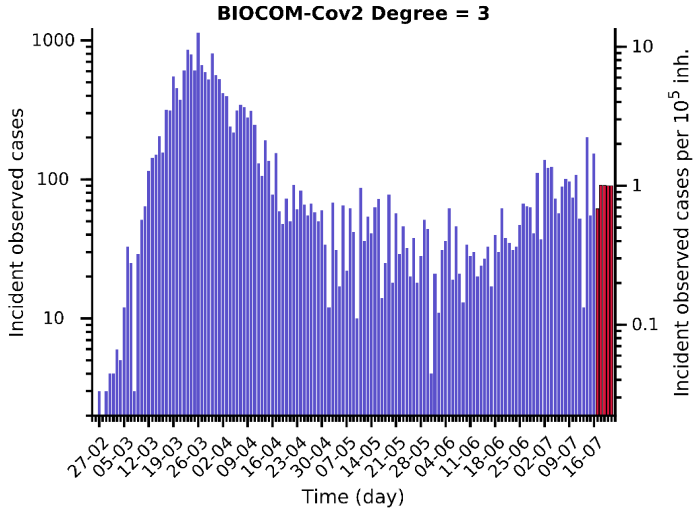


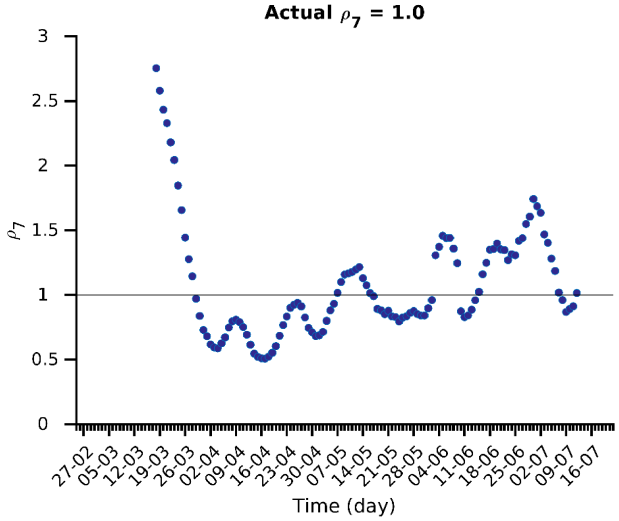
Austria 16-07-2020. Pop: 9.0M. Cumulative incidence: 214/10⁵

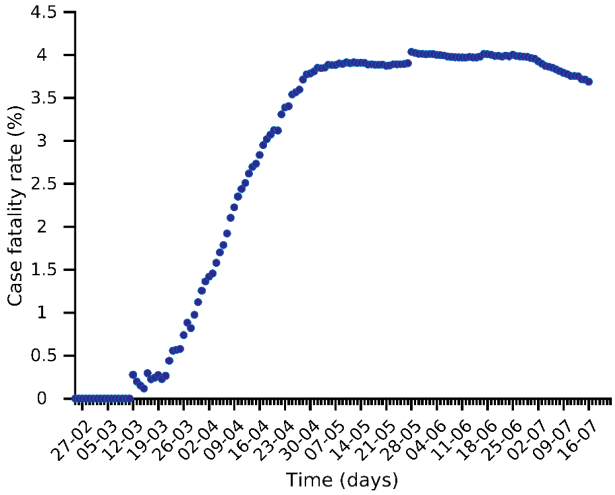


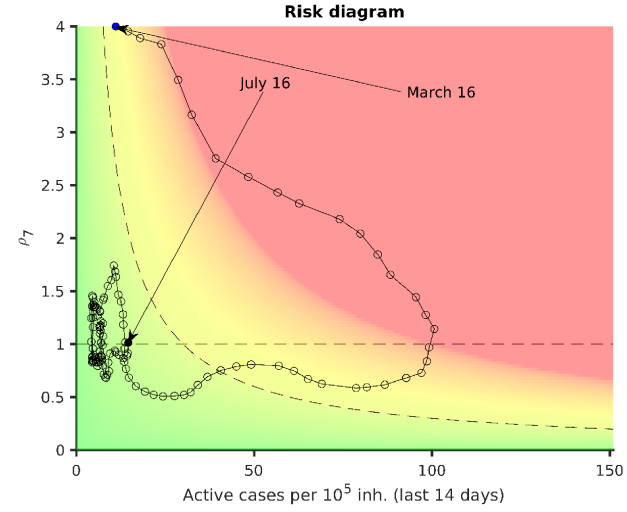


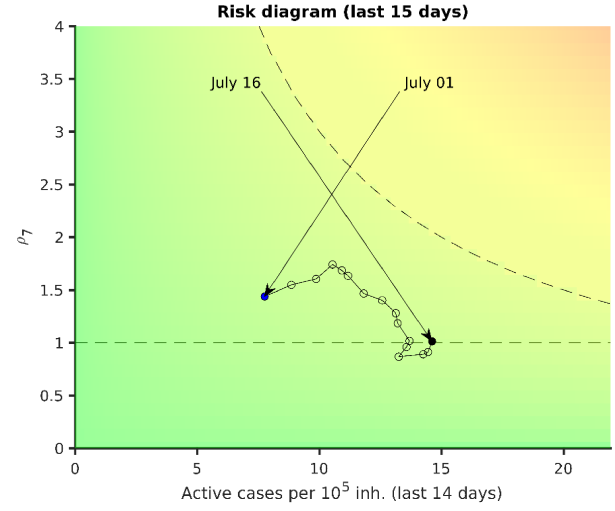




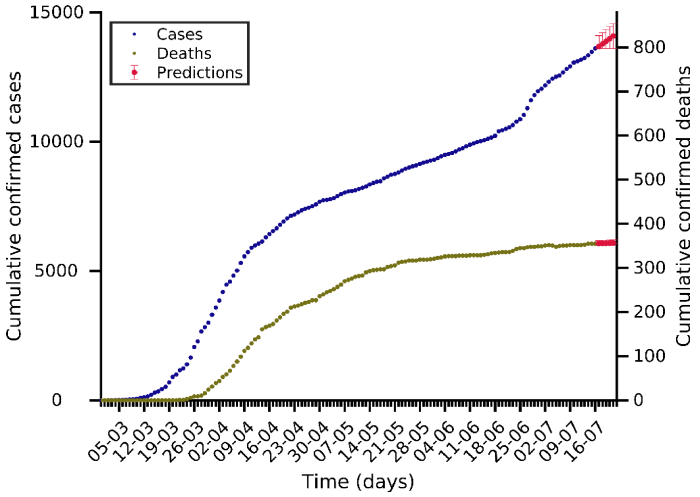


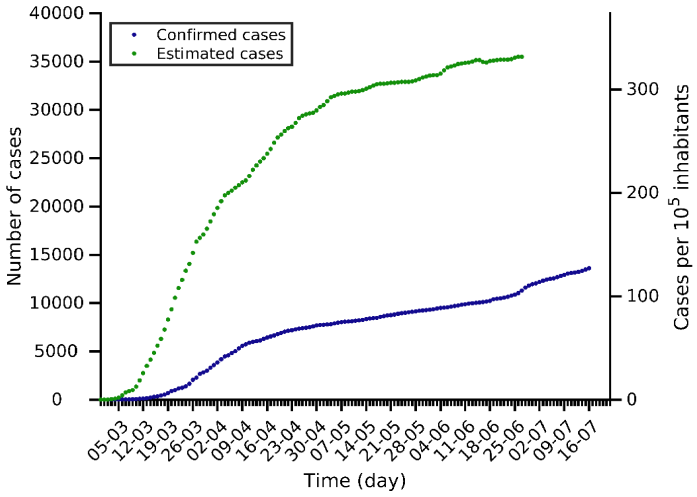


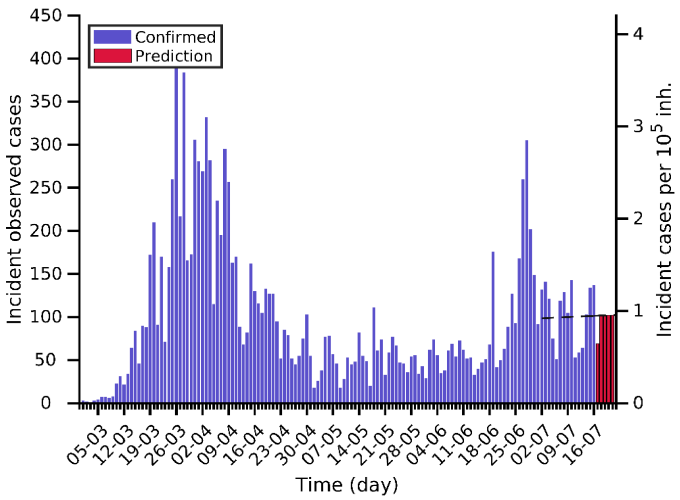


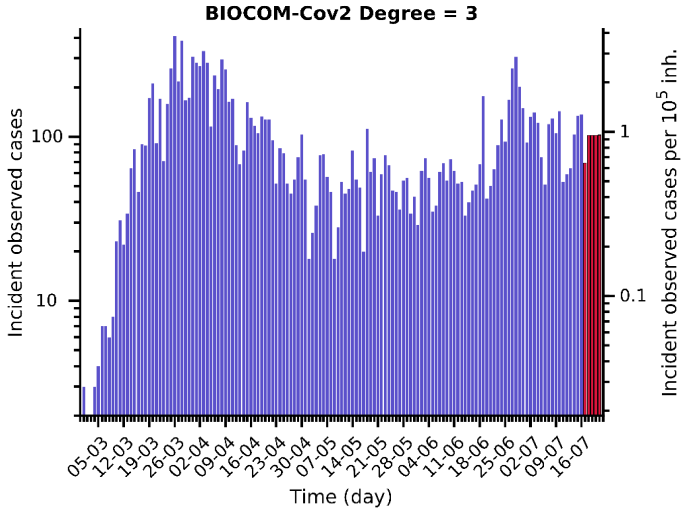


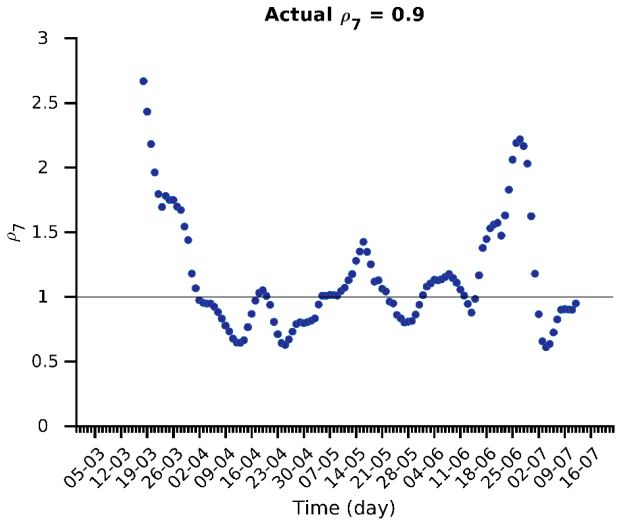
Czech Rep 16-07-2020. Pop: 10.7M. Cumulative incidence: 127/10^5

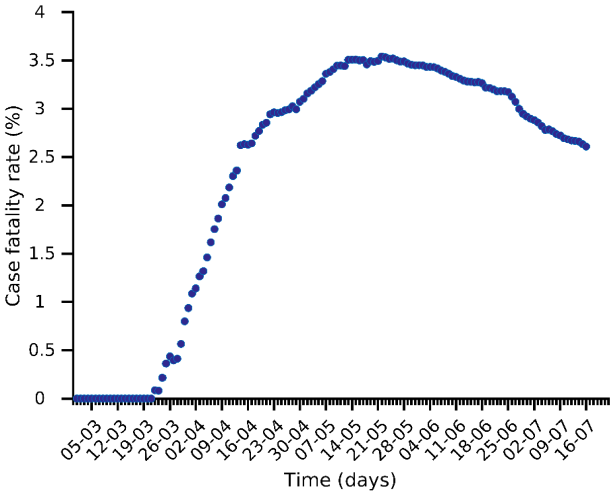


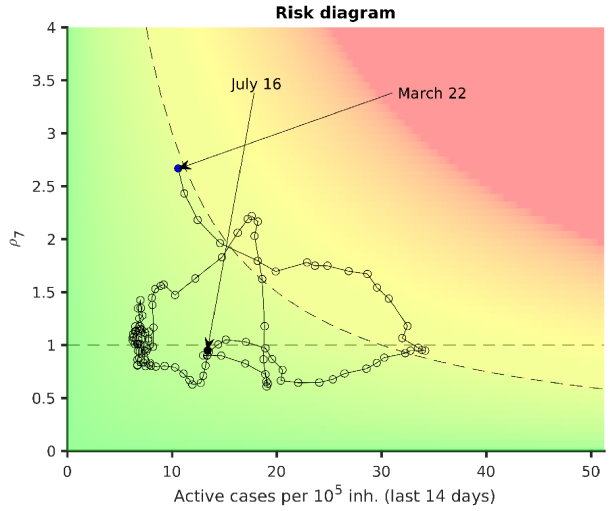


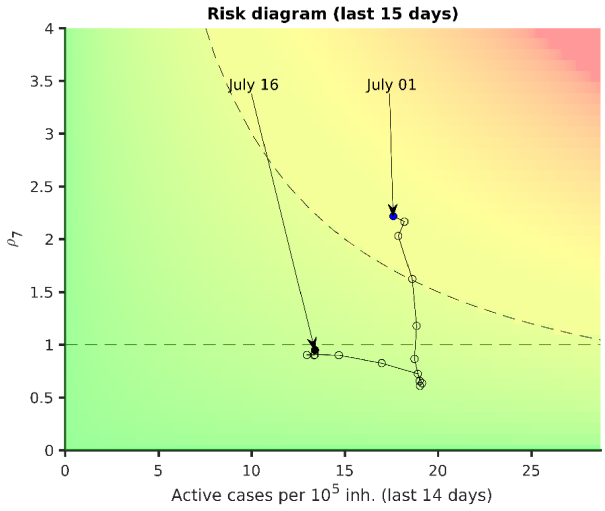




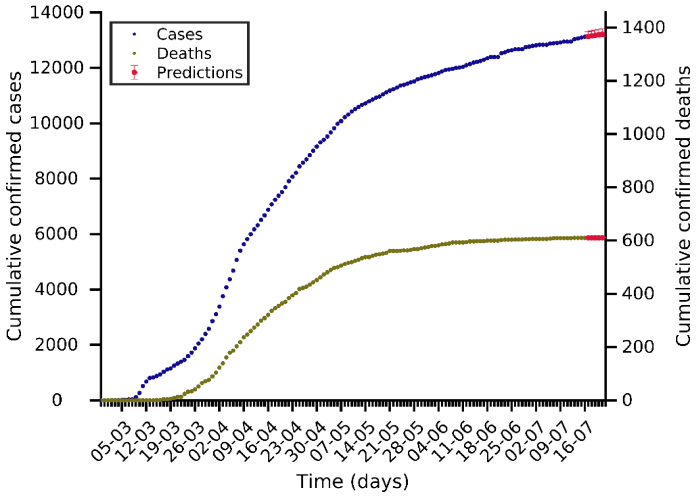


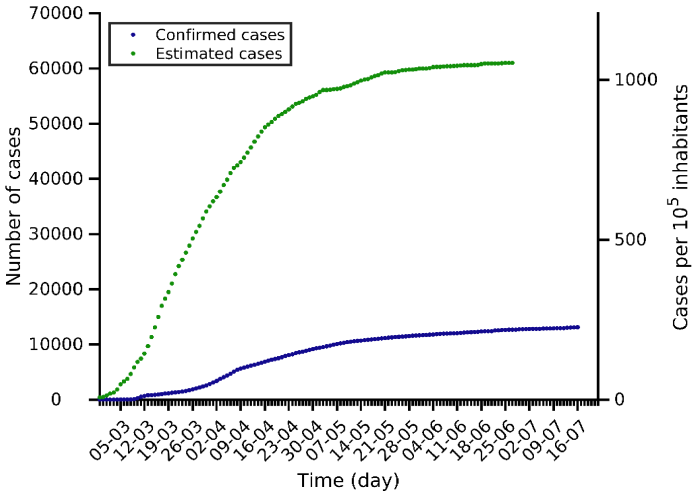


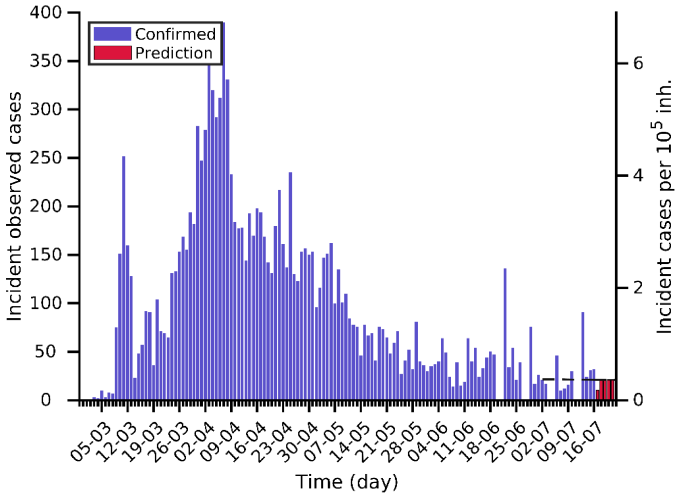


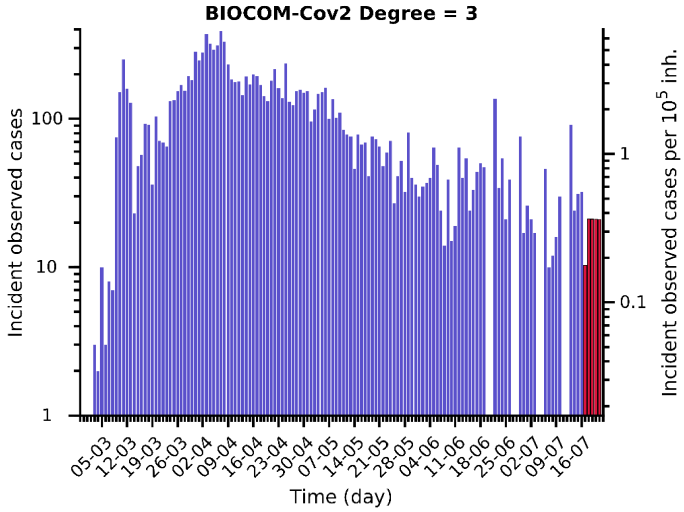


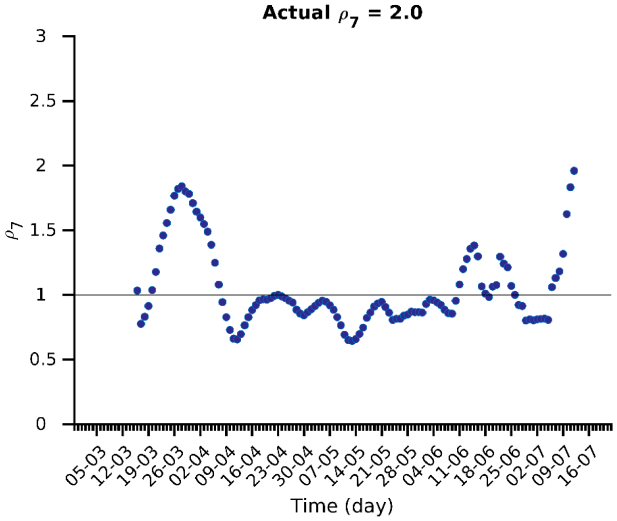
Denmark 16-07-2020. Pop: 5.8M. Cumulative incidence: 227/10⁵

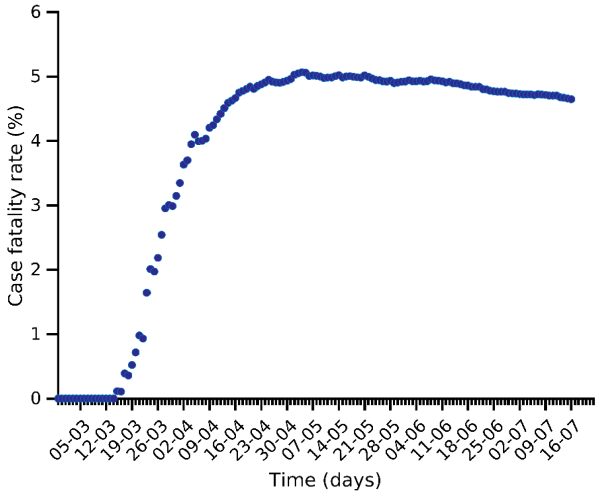


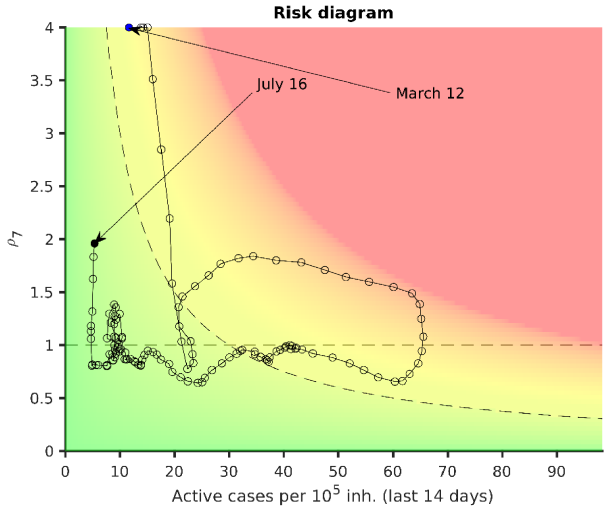


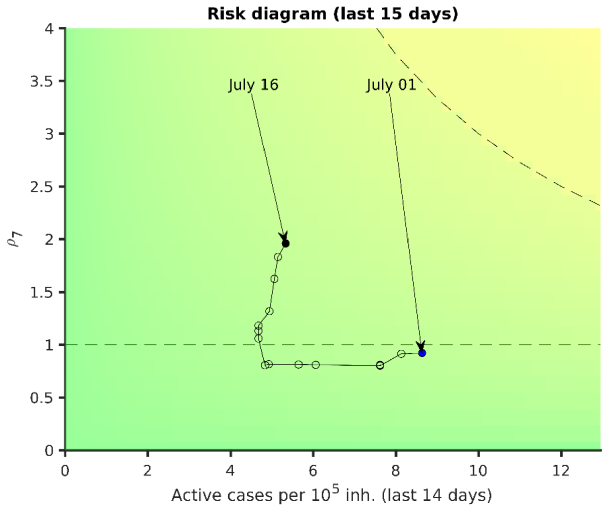




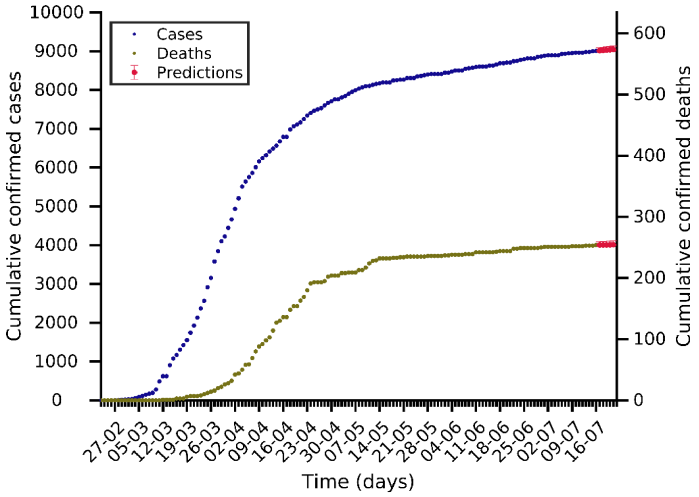


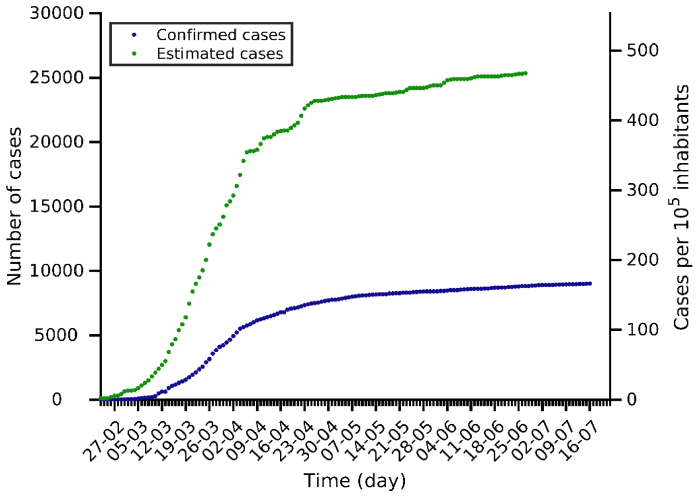


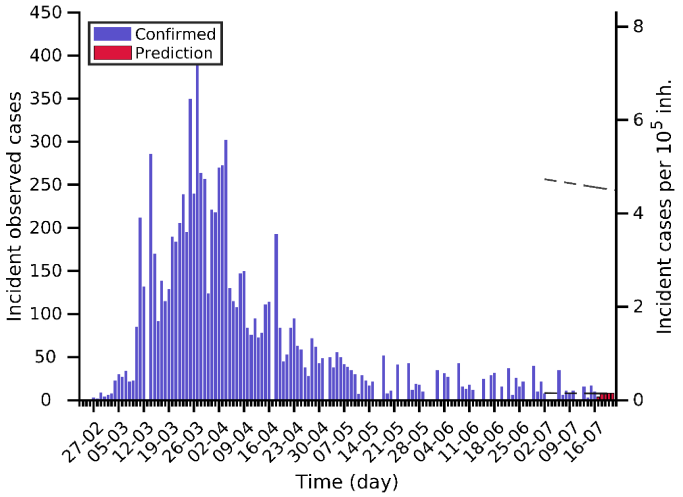


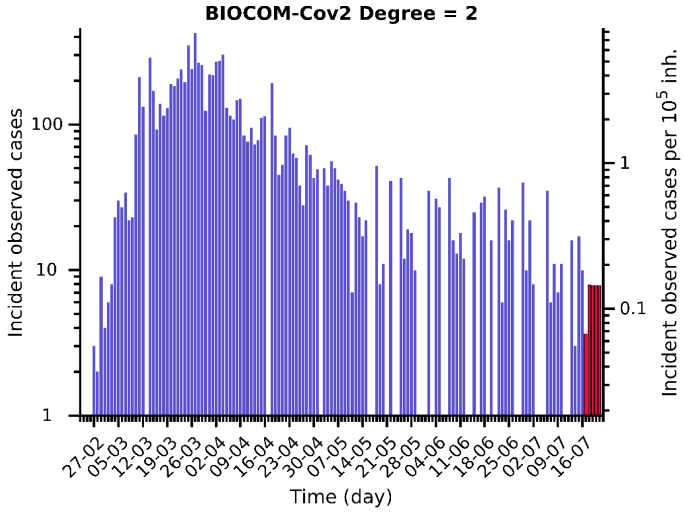


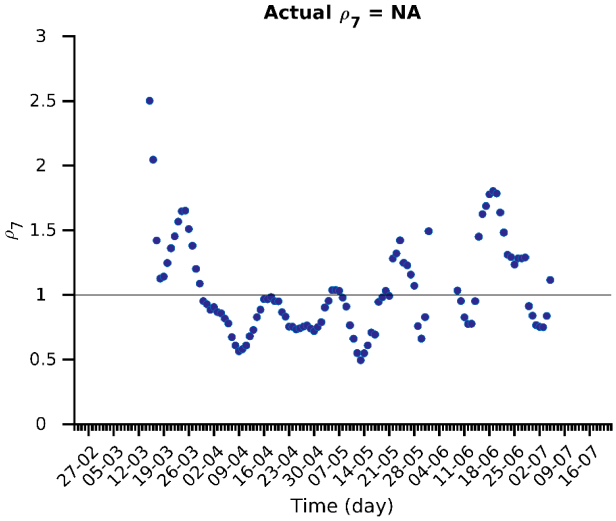
Norway 16-07-2020. Pop: 5.4M. Cumulative incidence: 166/10⁵

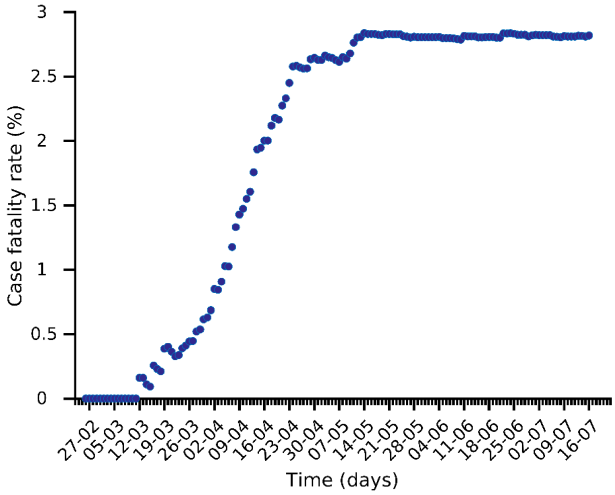


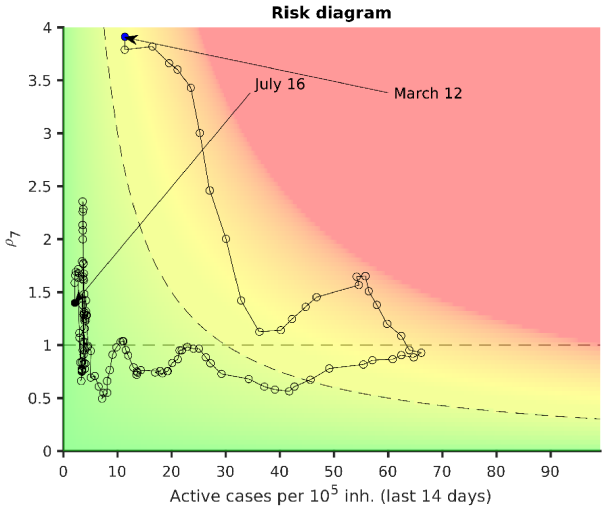


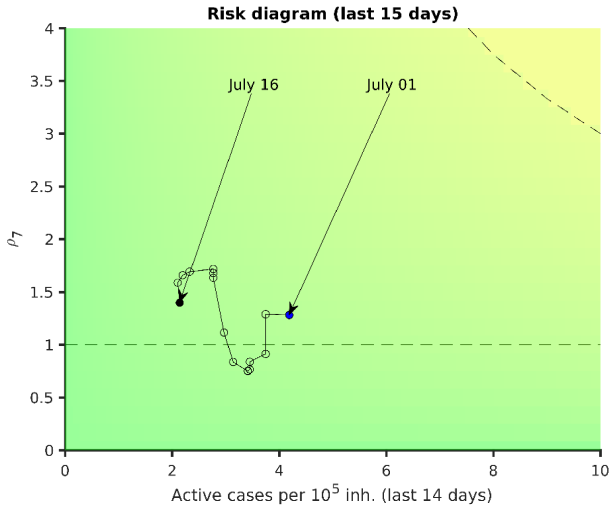




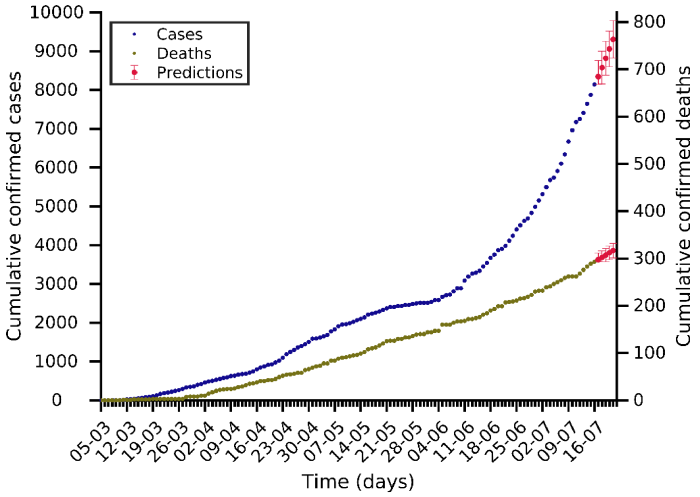


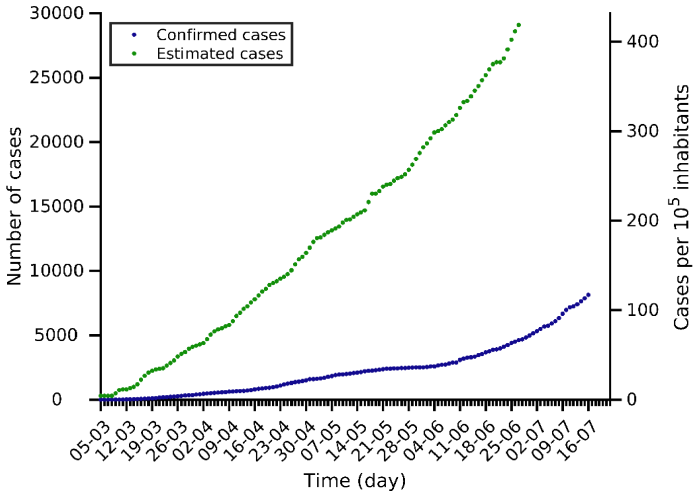


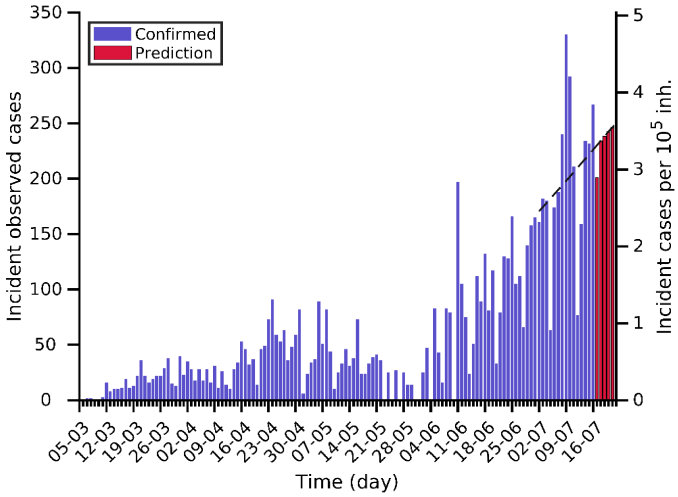


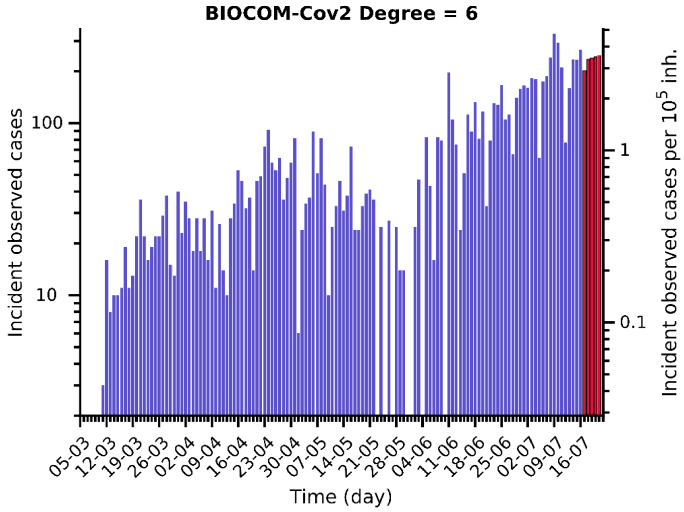


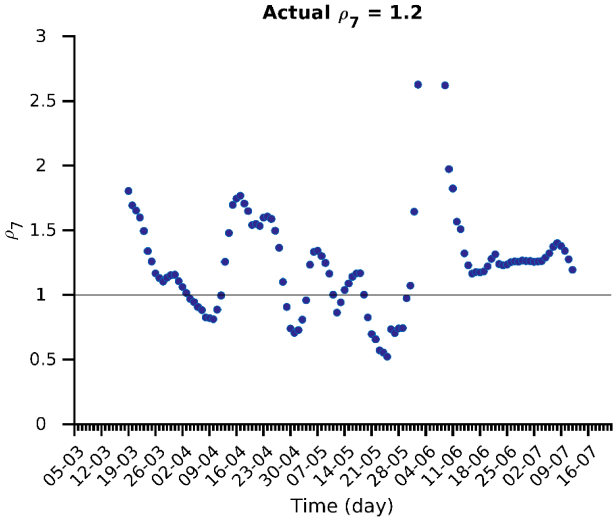
Bulgaria 16-07-2020. Pop: 6.9M. Cumulative incidence: 117/10⁵

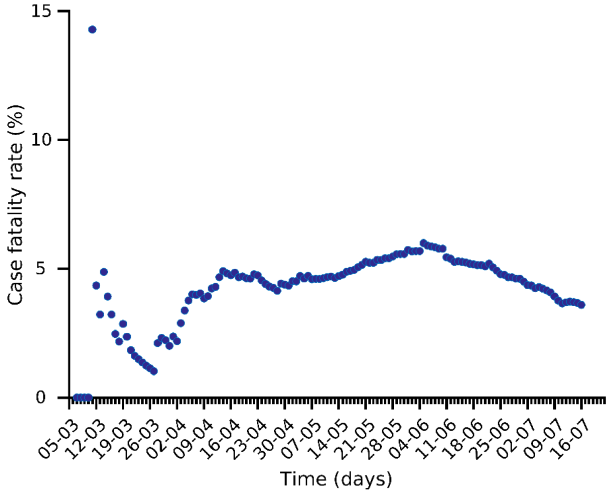


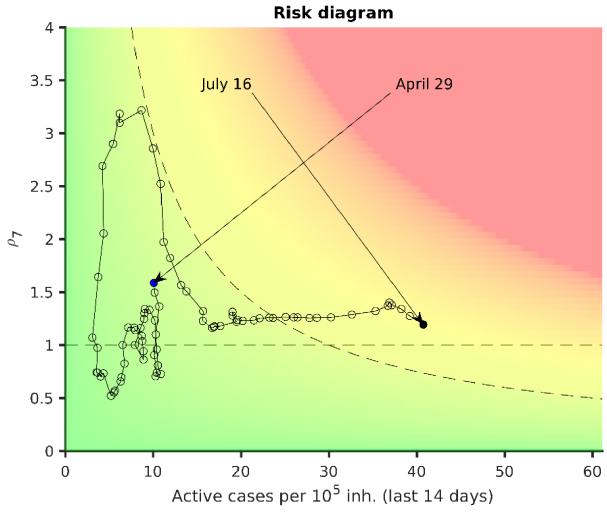


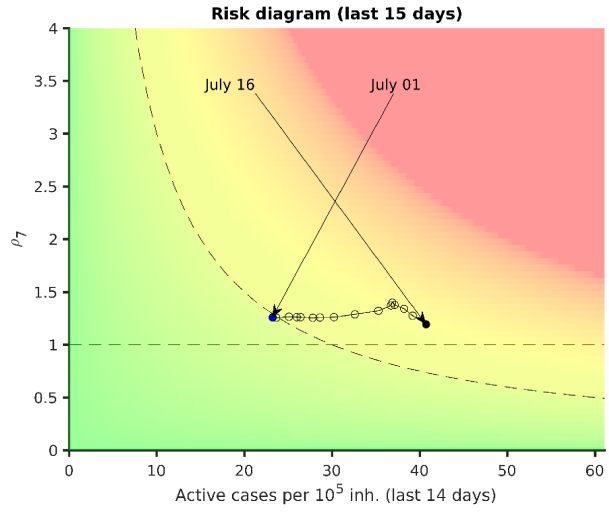




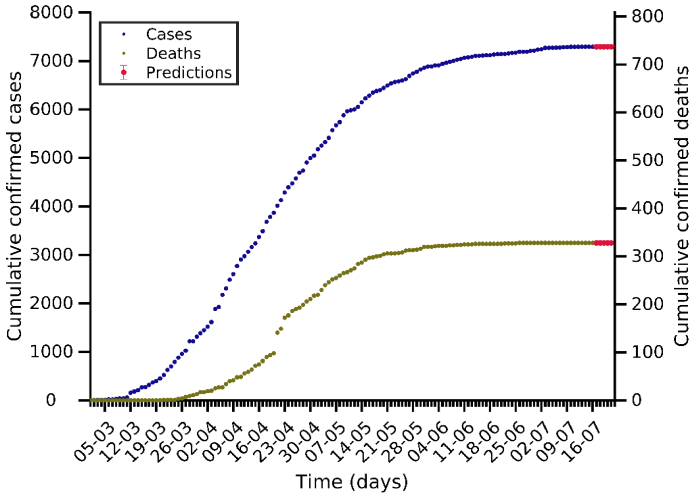


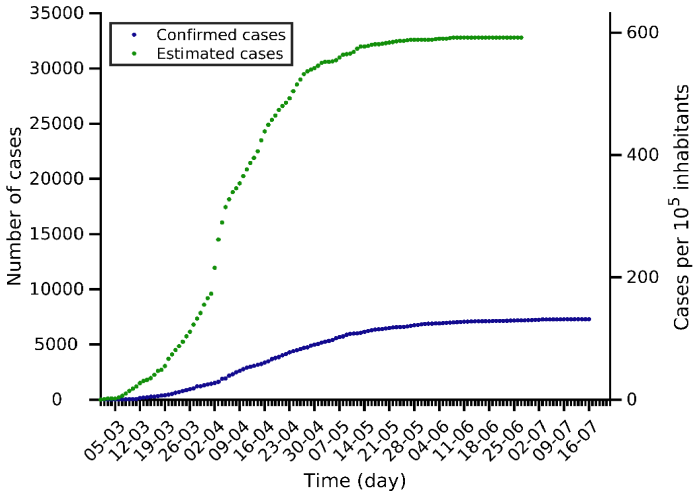


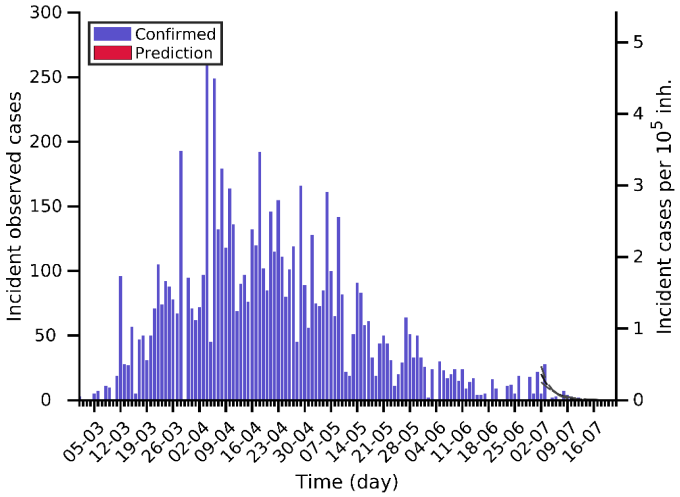


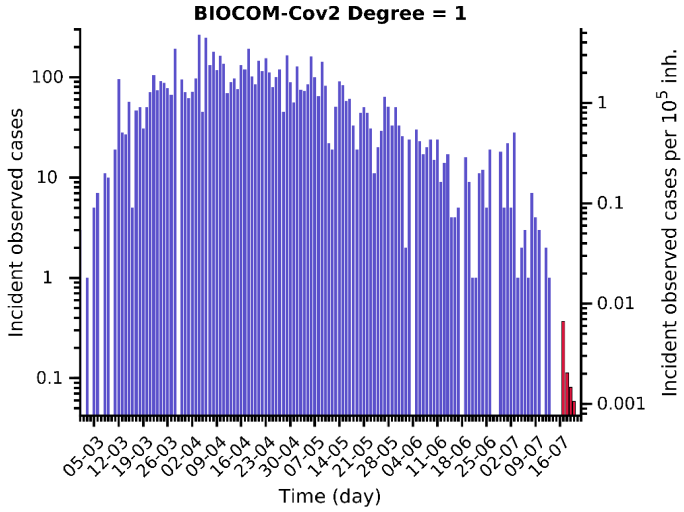


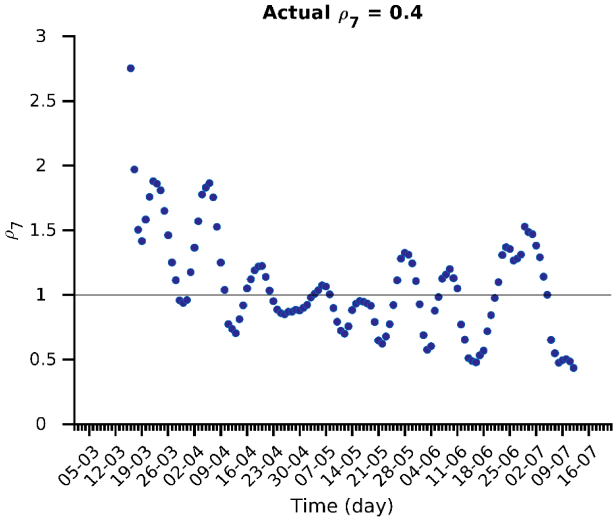
Finland 16-07-2020. Pop: 5.5M. Cumulative incidence: 132/10⁵

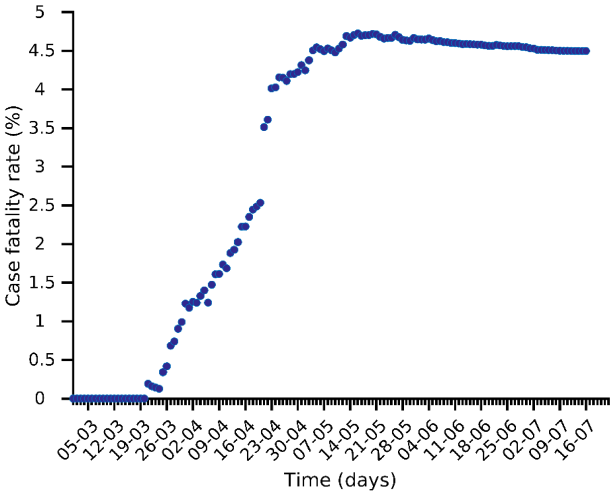


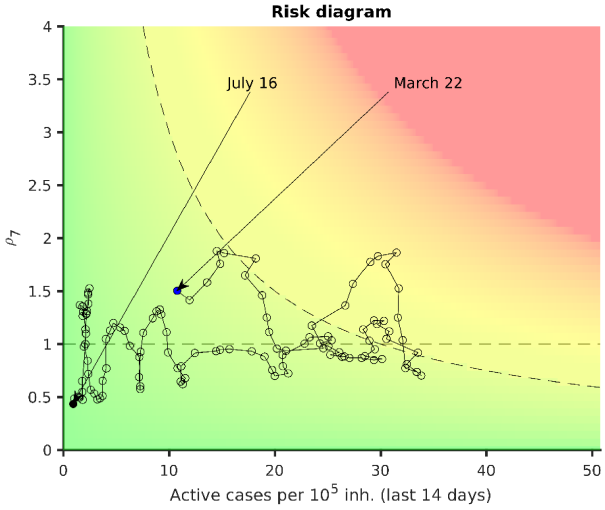


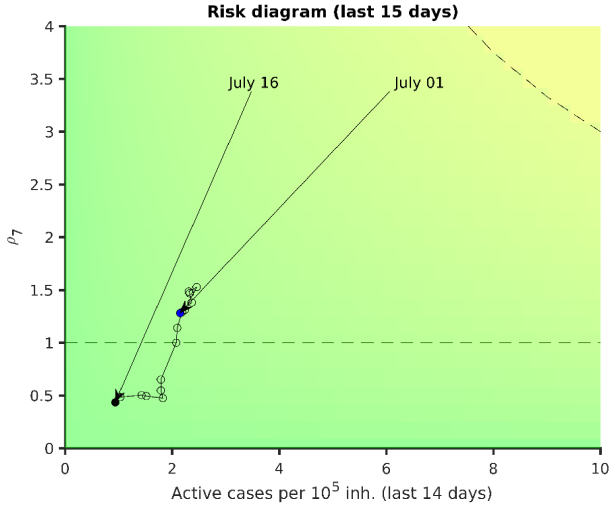




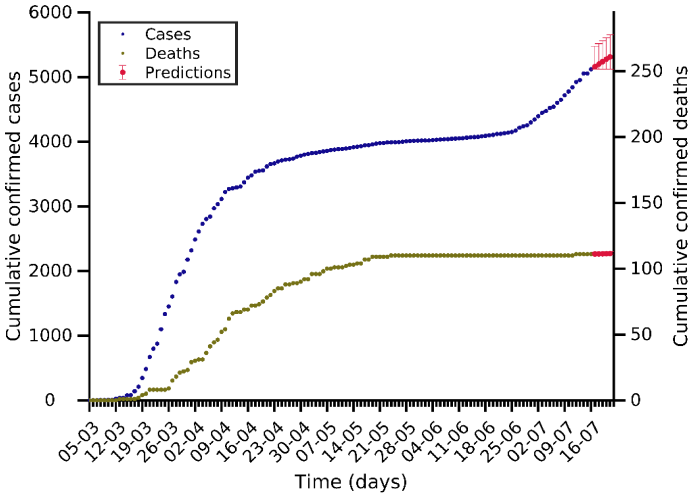


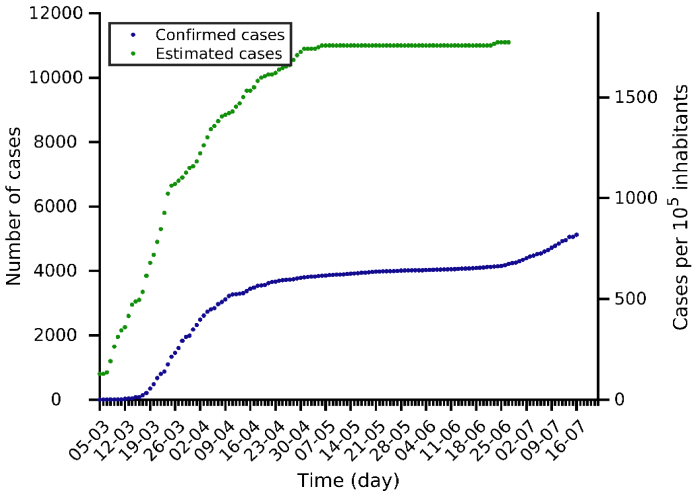


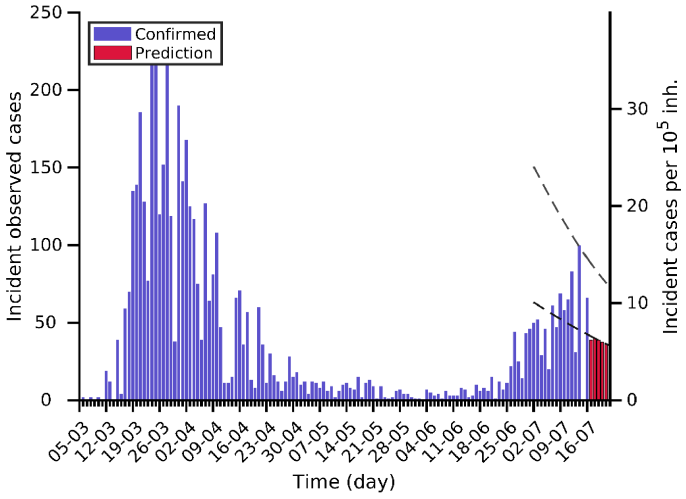


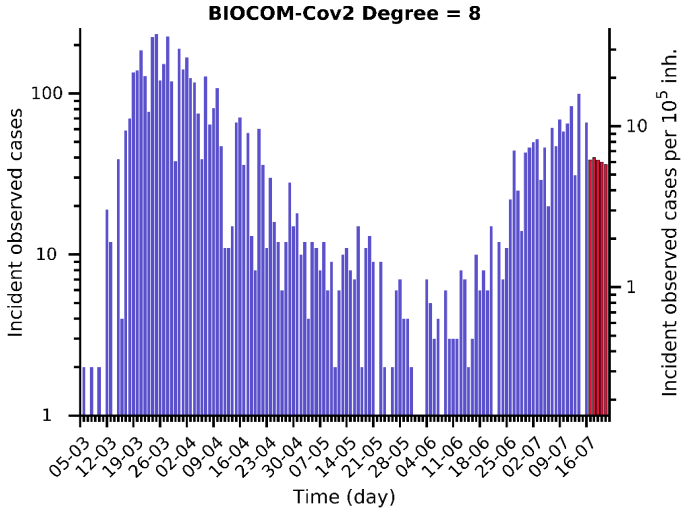


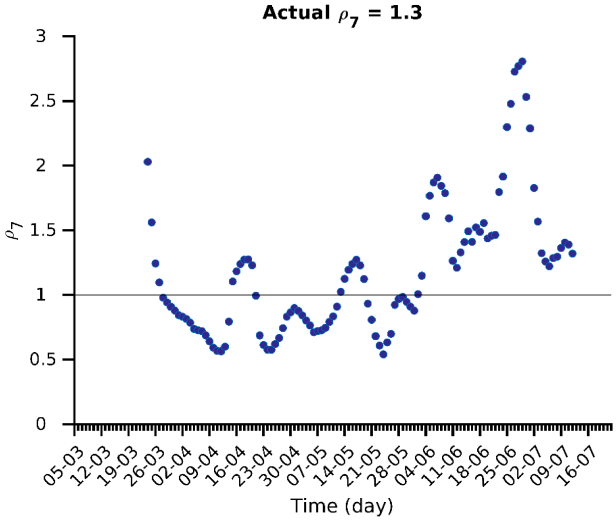
Luxembourg 16-07-2020. Pop: 0.6M. Cumulative incidence: 818/10⁵

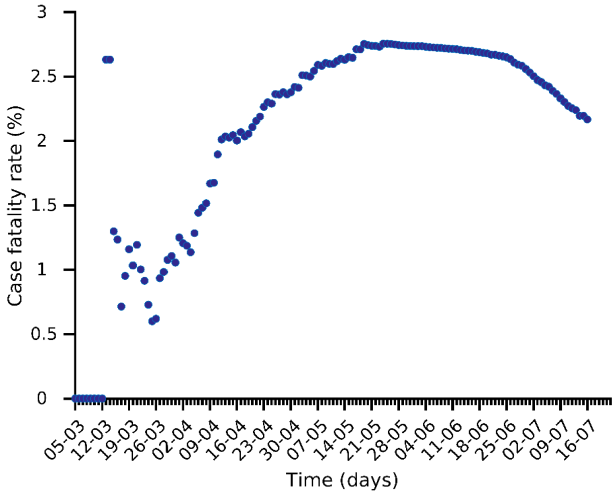


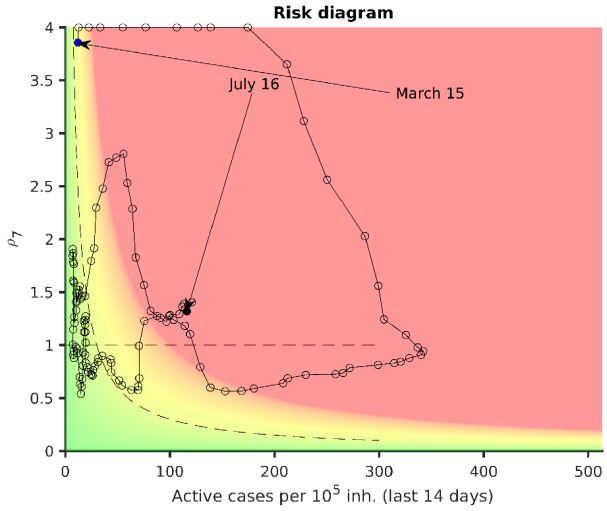


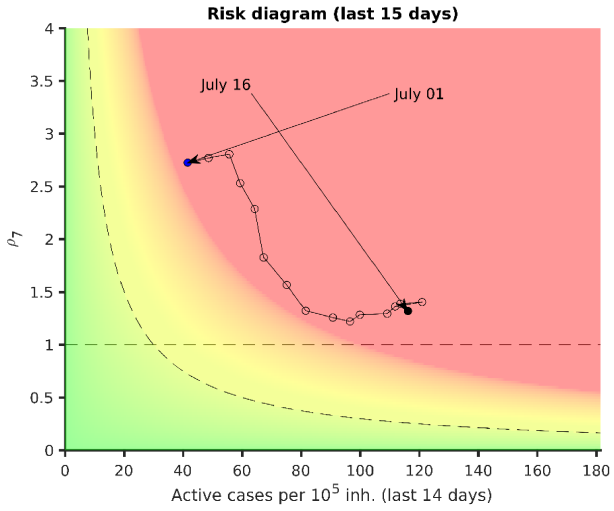




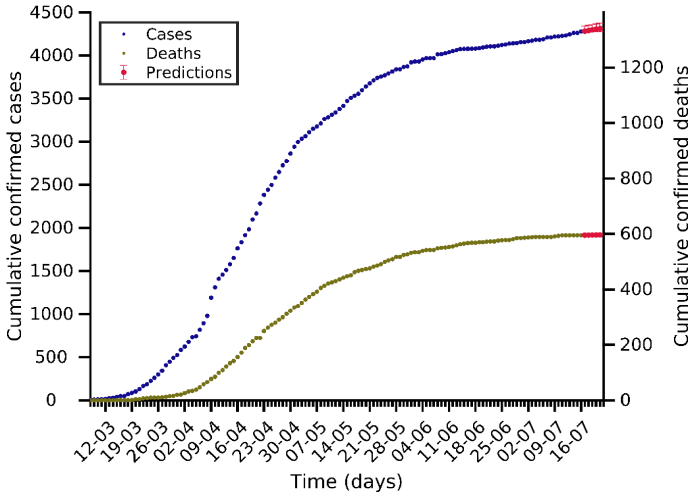


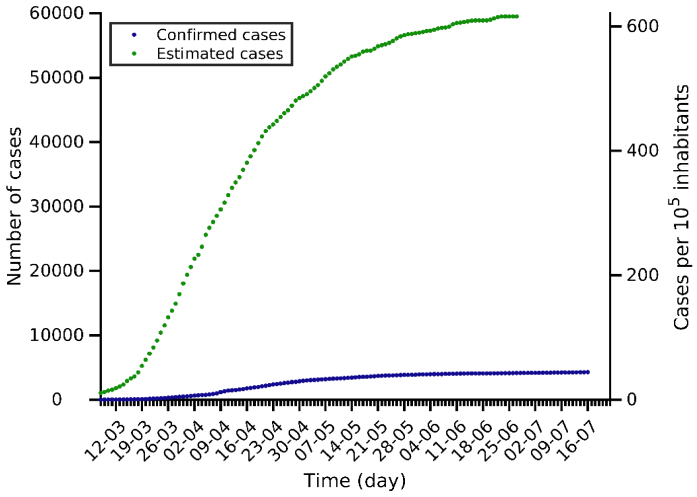


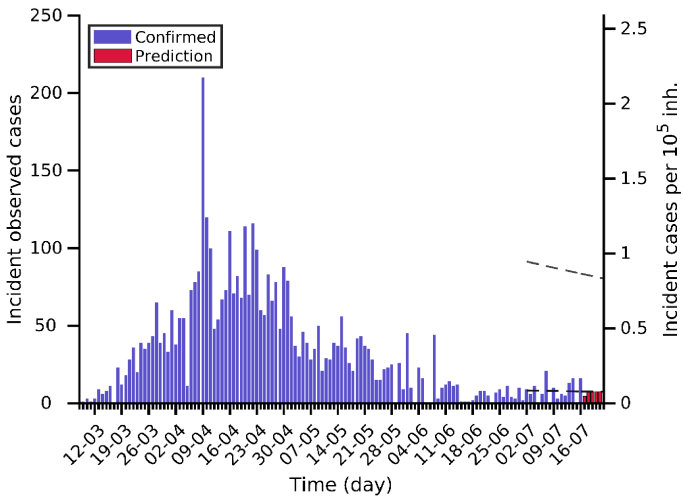


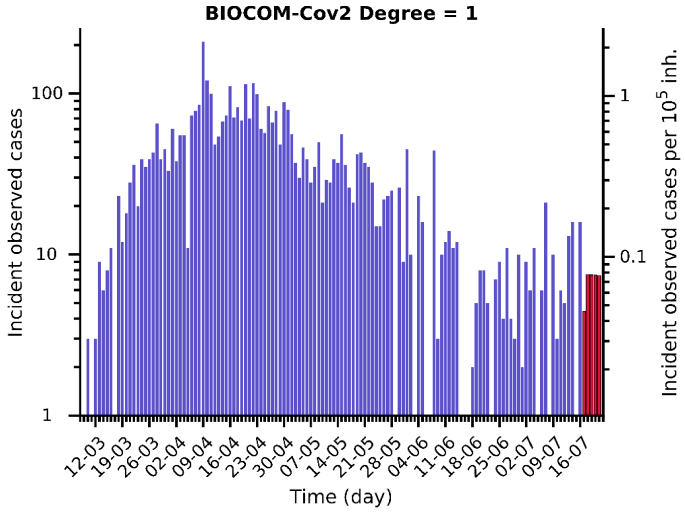


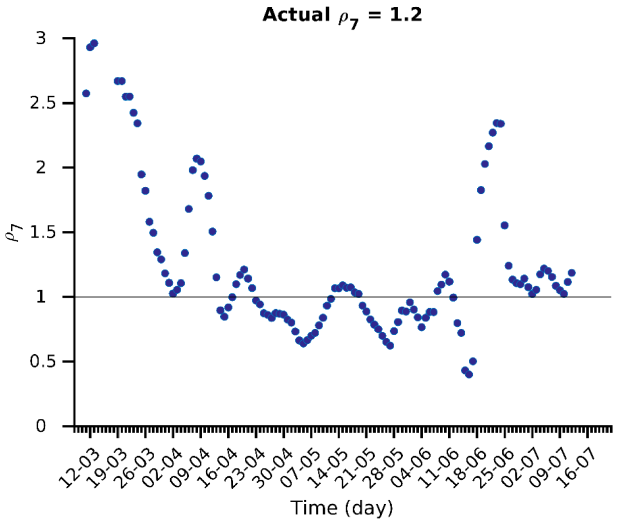
Hungary 16-07-2020. Pop: 9.7M. Cumulative incidence: 44/10⁵

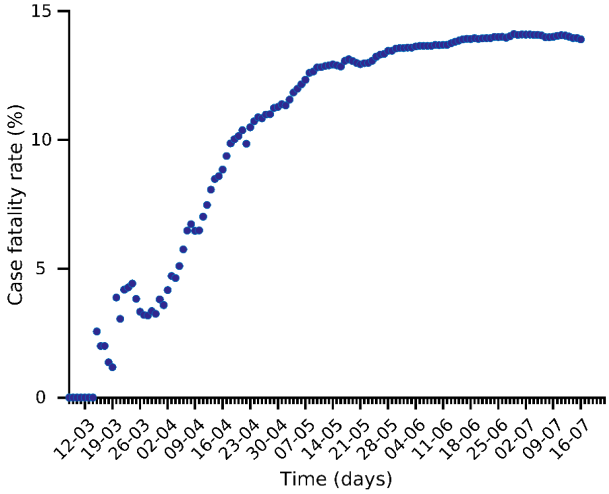


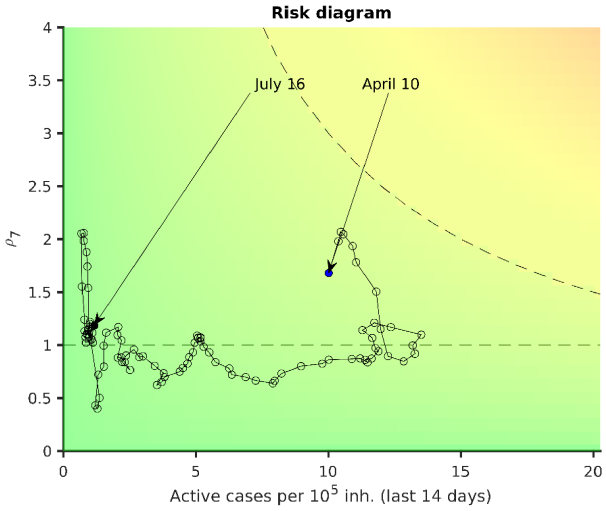


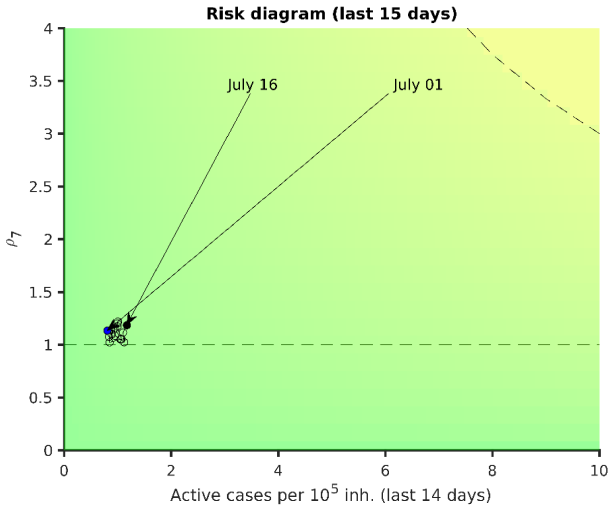




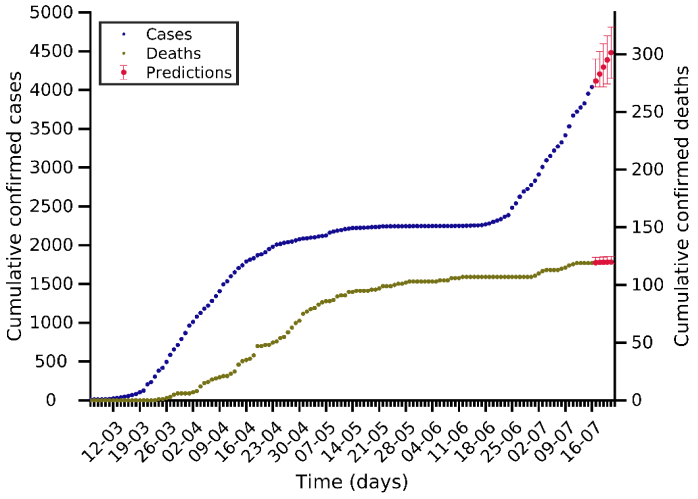


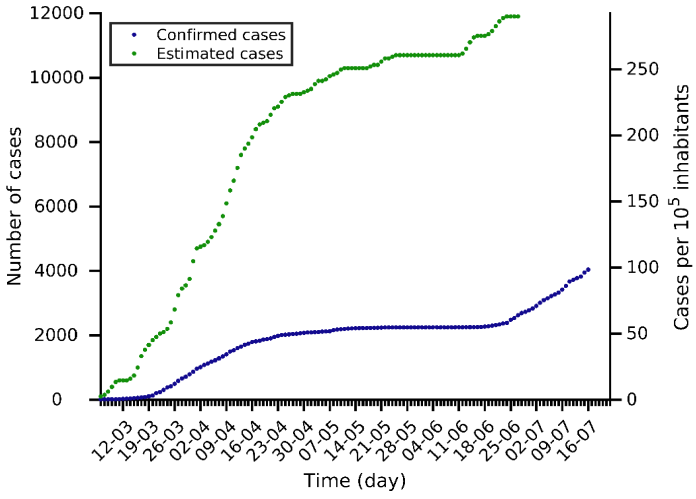


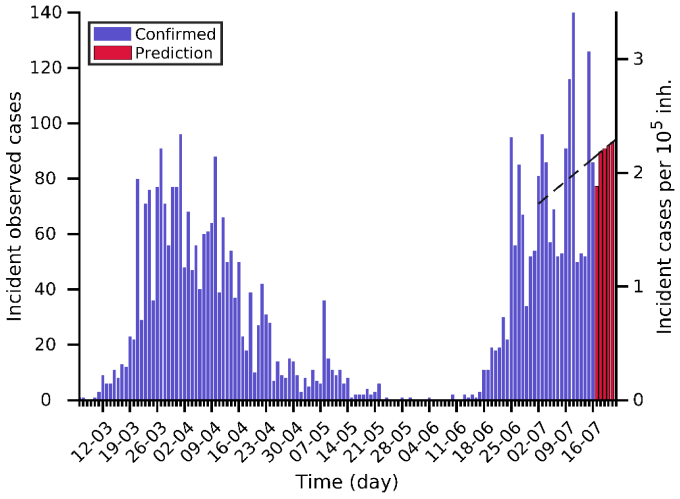


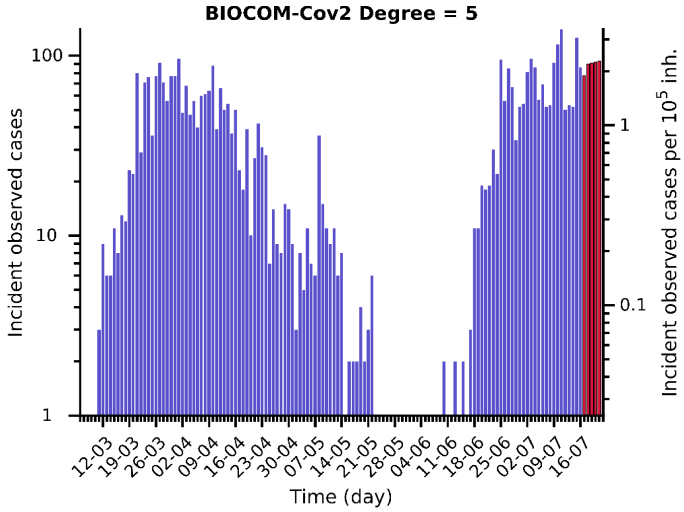


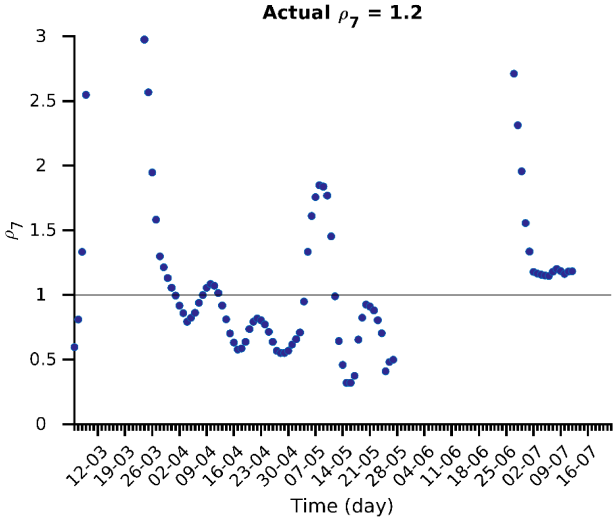
Croatia 16-07-2020. Pop: 4.1M. Cumulative incidence: 98/10^5

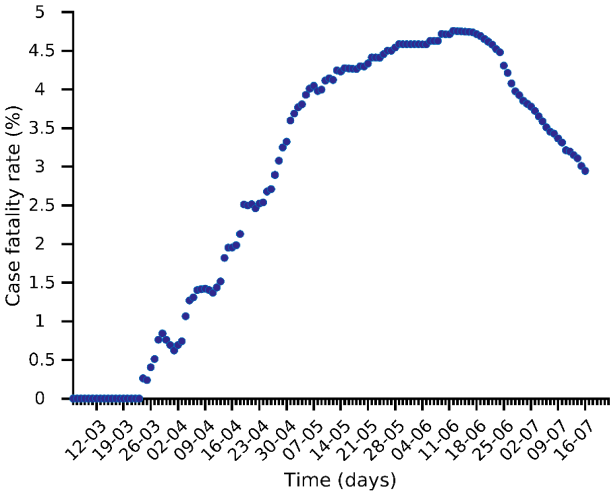


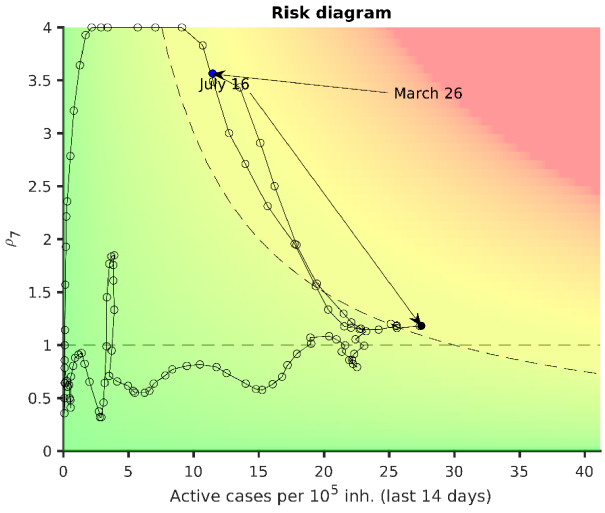


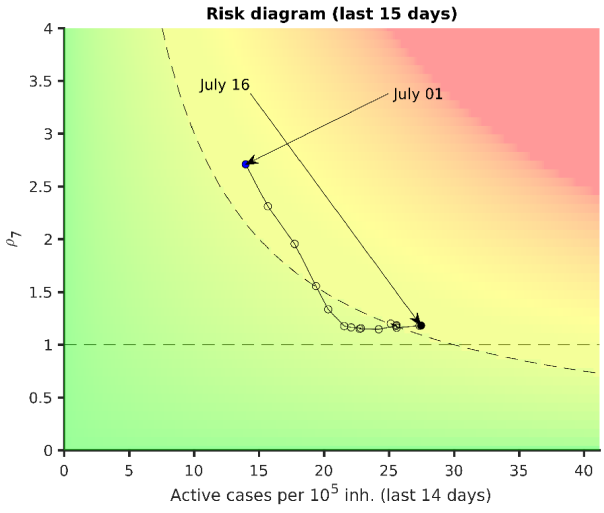




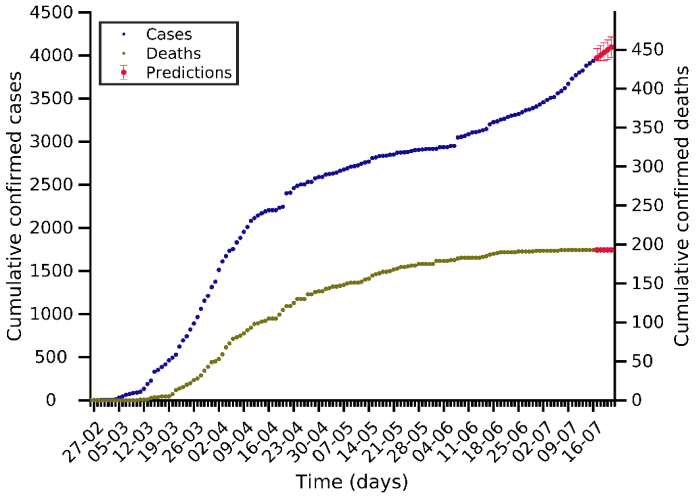


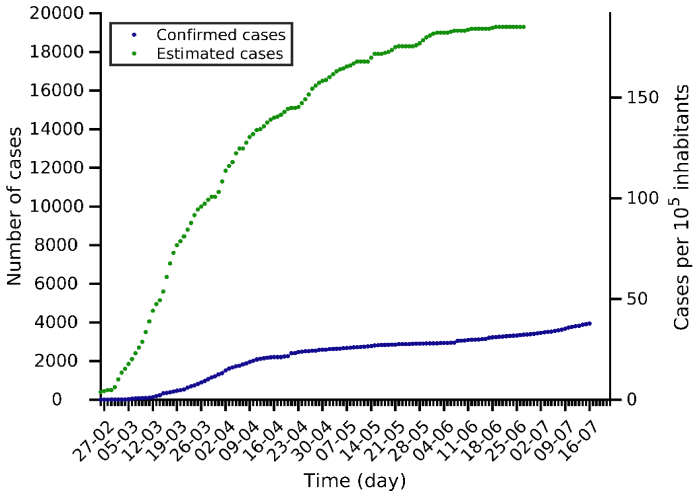


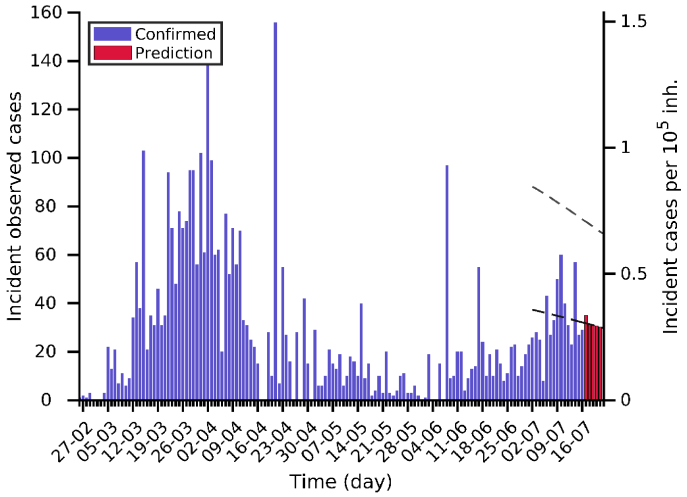


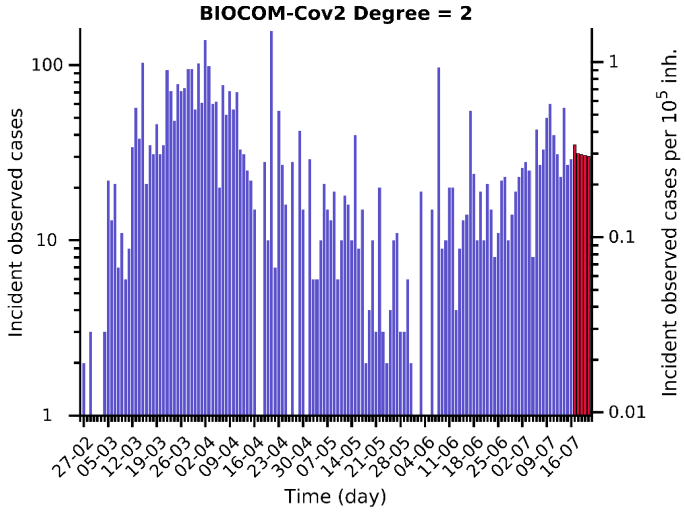


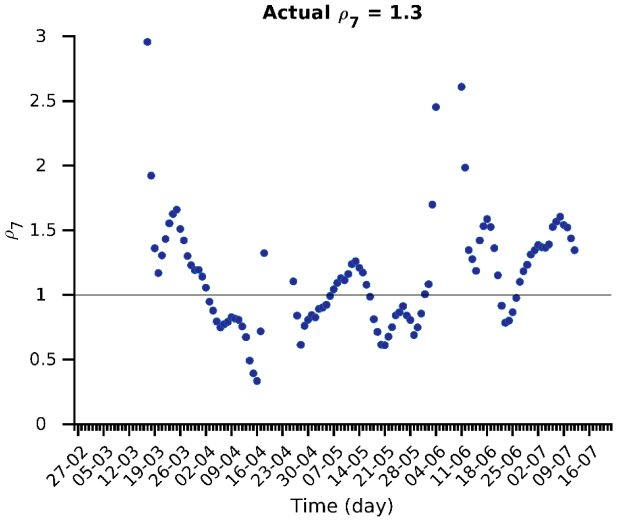
Greece 16-07-2020. Pop: 10.4M. Cumulative incidence: $38/10^5$

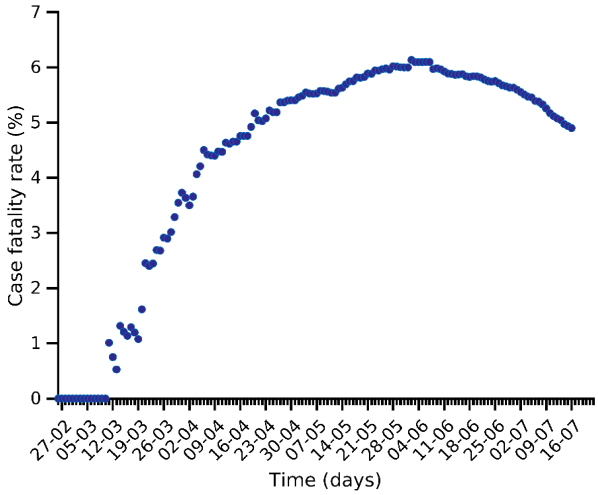


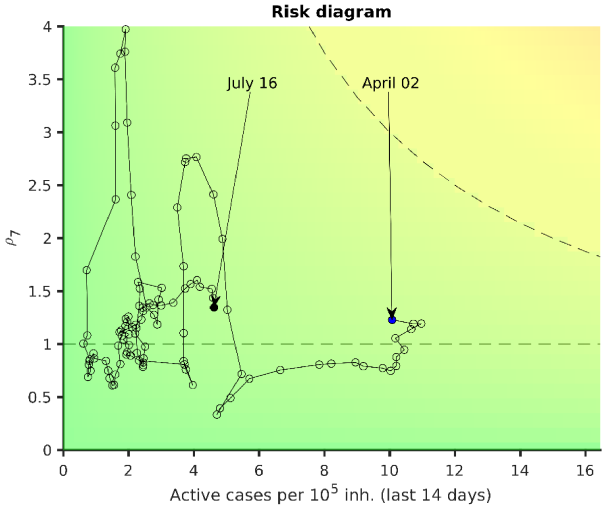


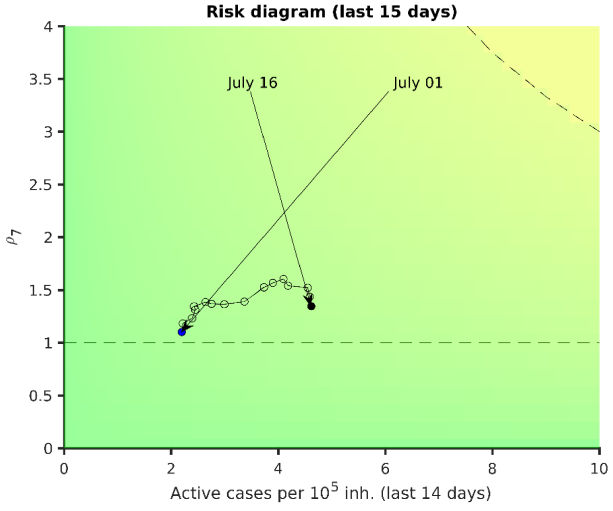




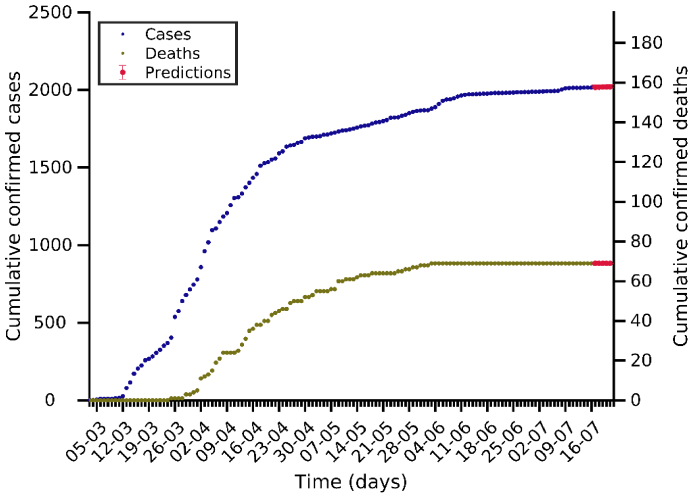


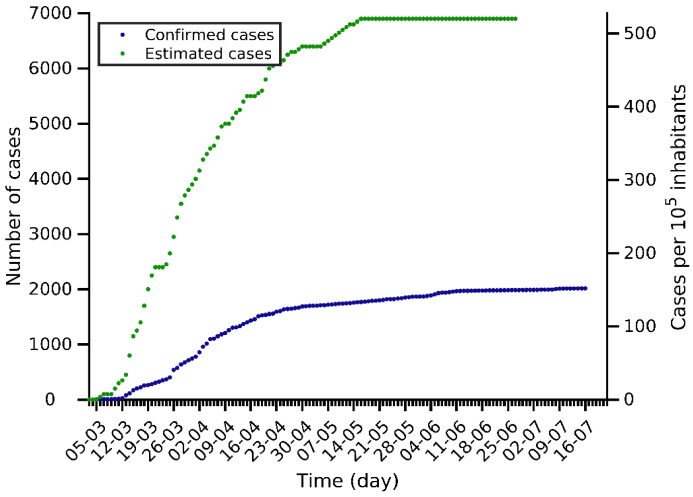


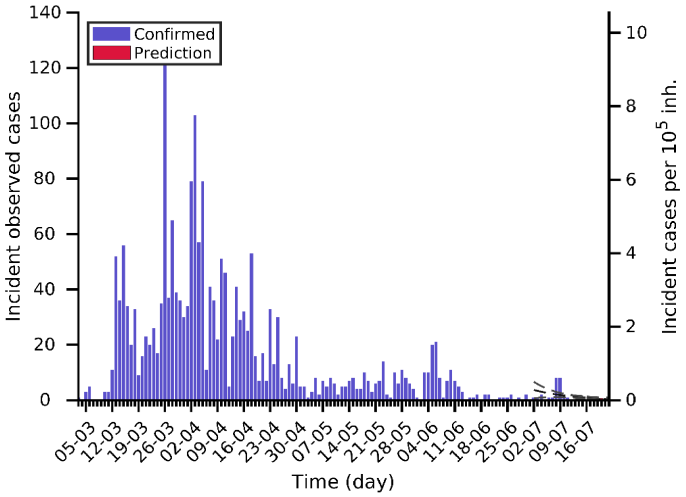


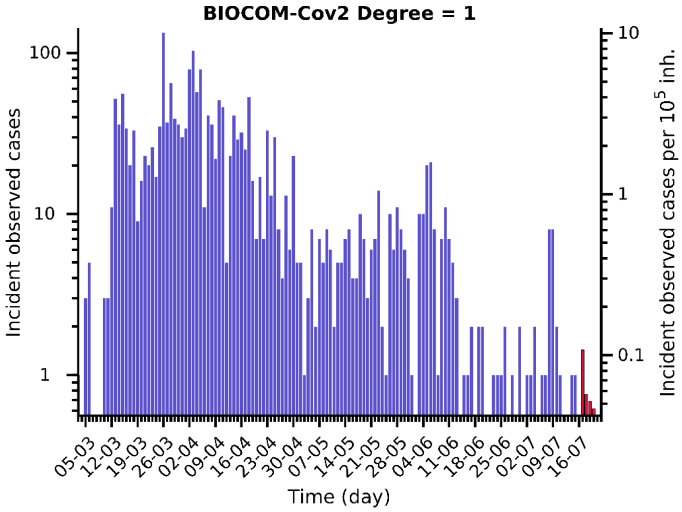


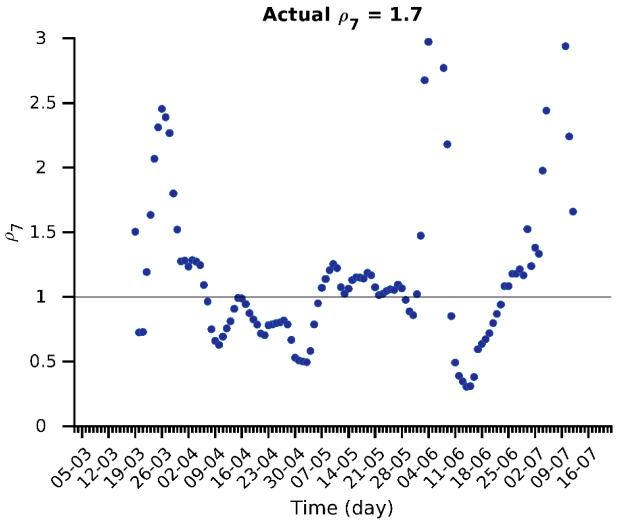
Estonia 16-07-2020. Pop: 1.3M. Cumulative incidence: 152/10⁵

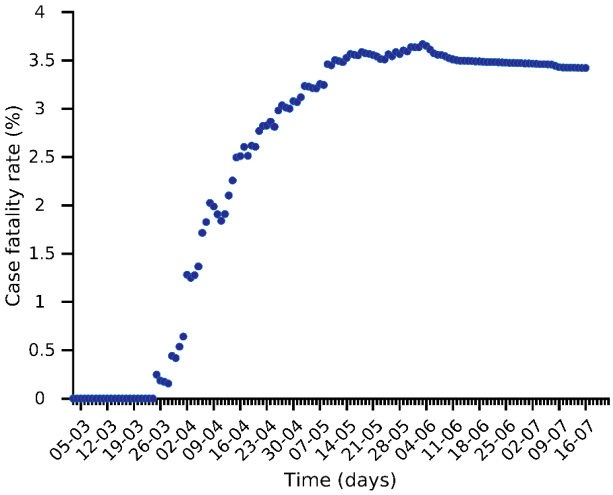


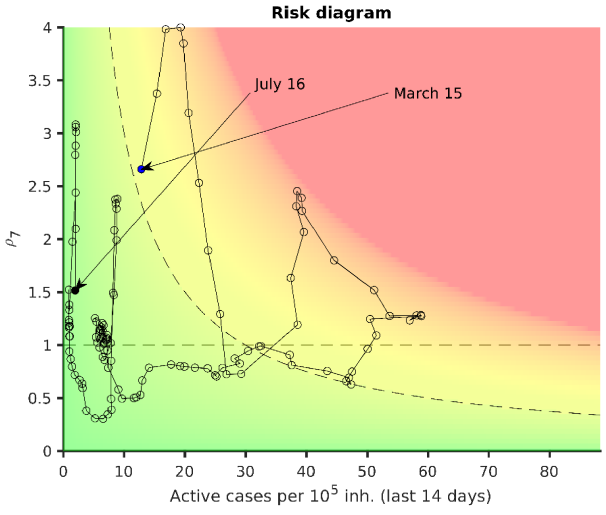


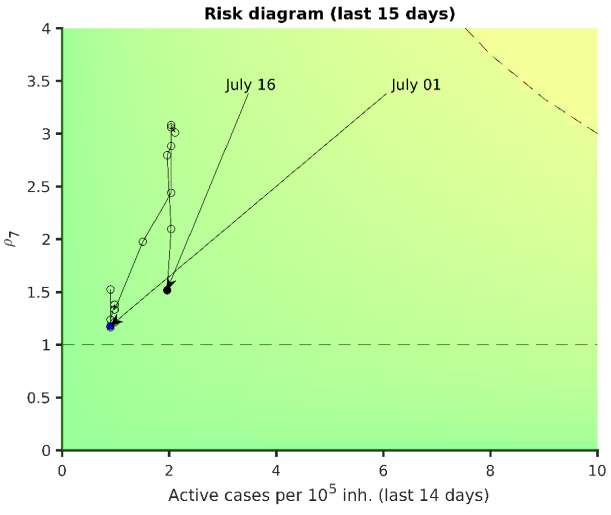




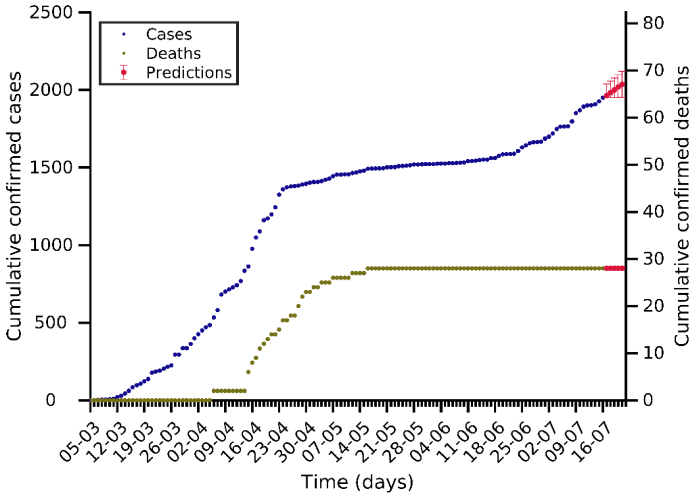


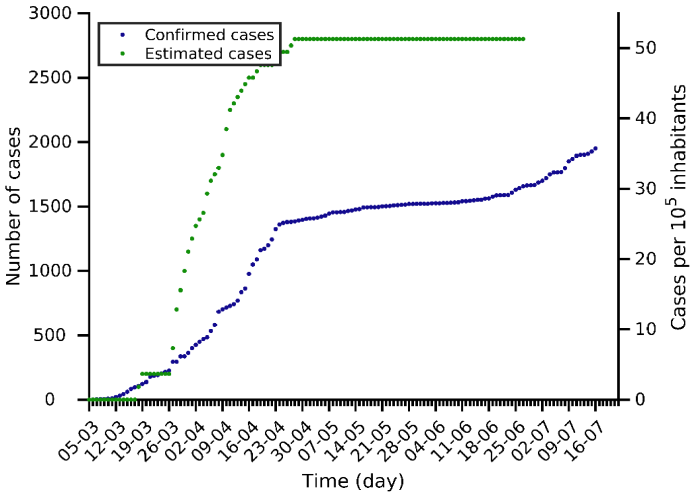


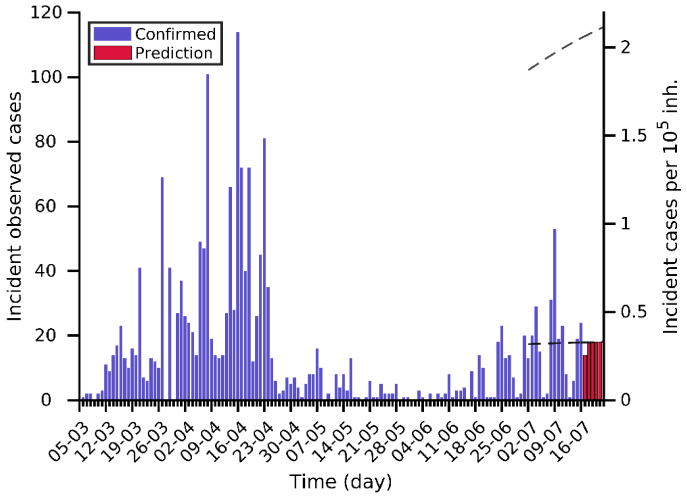


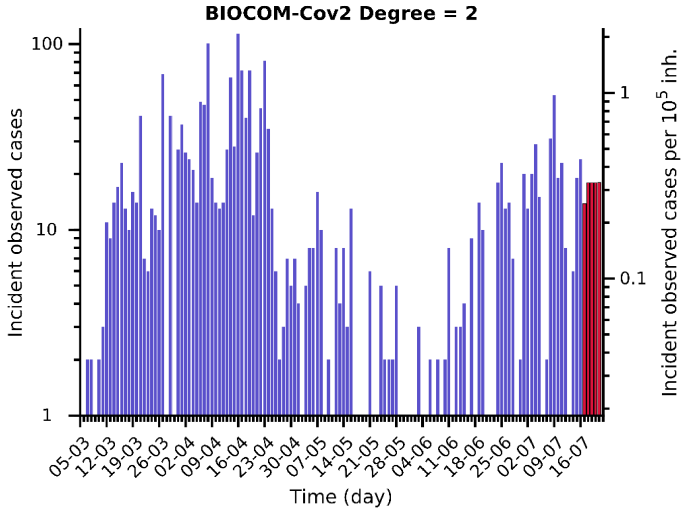


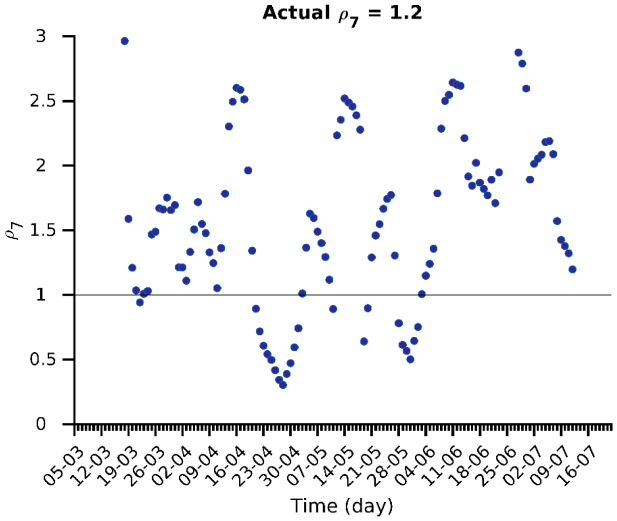
Slovakia 16-07-2020. Pop: 5.5M. Cumulative incidence: 36/10⁵

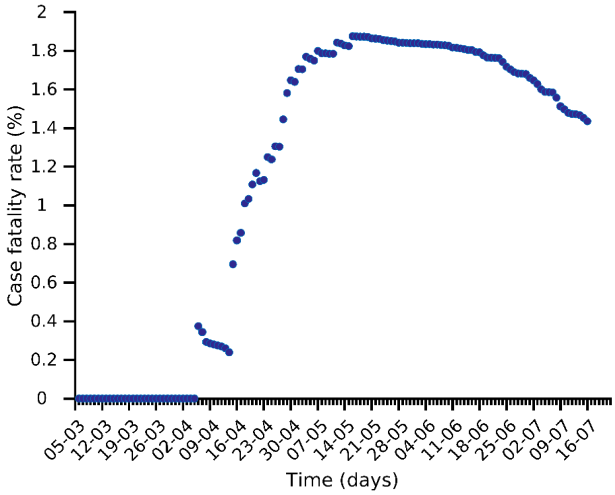


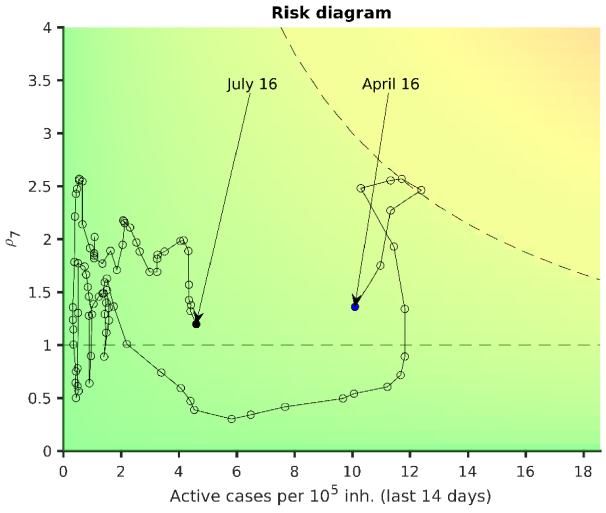


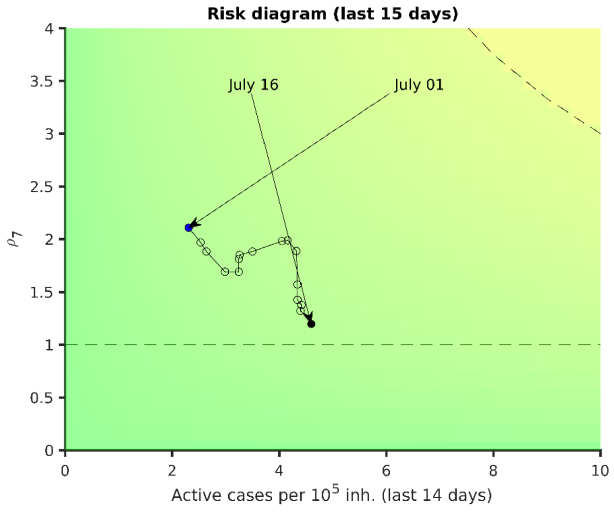




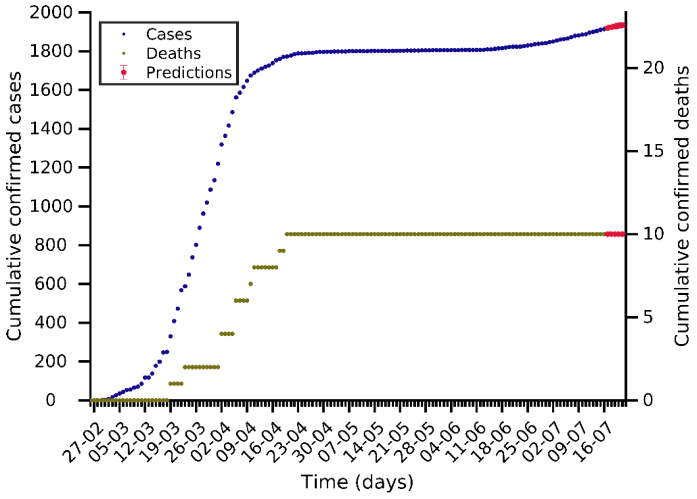


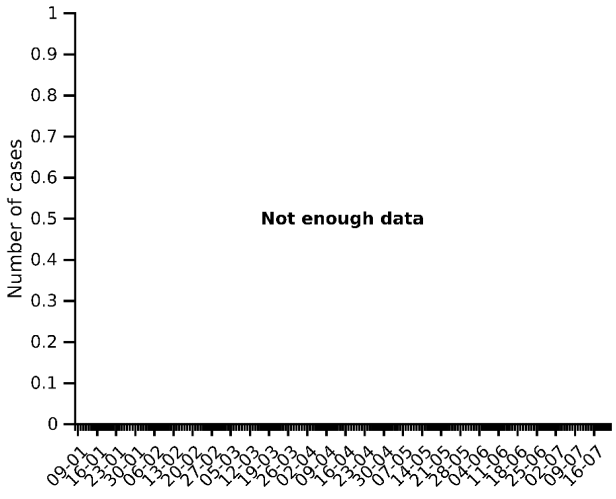


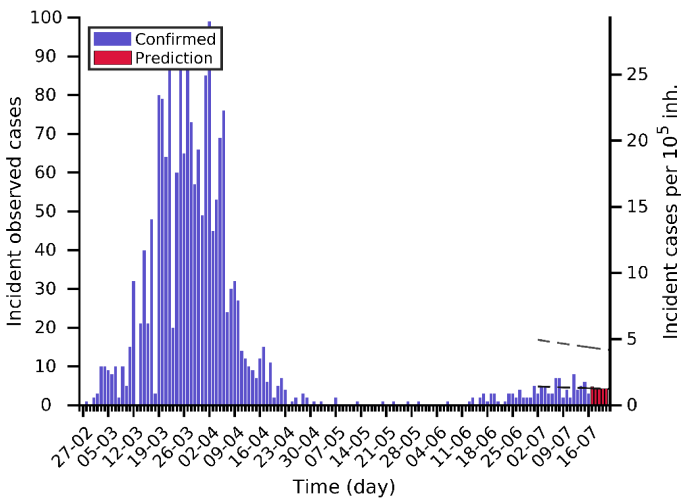


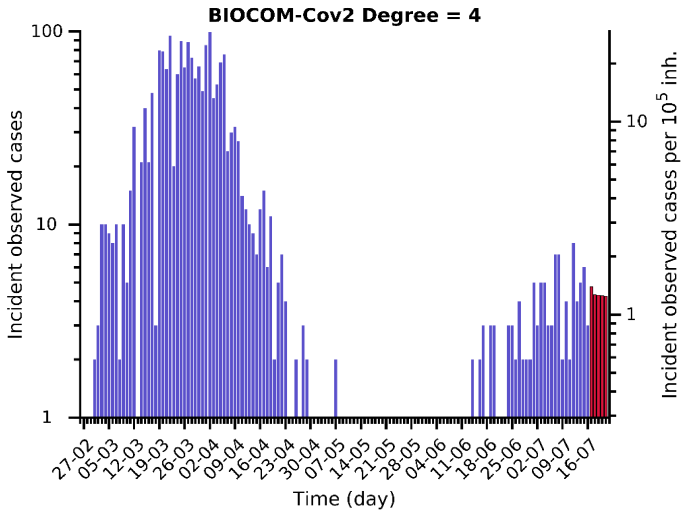


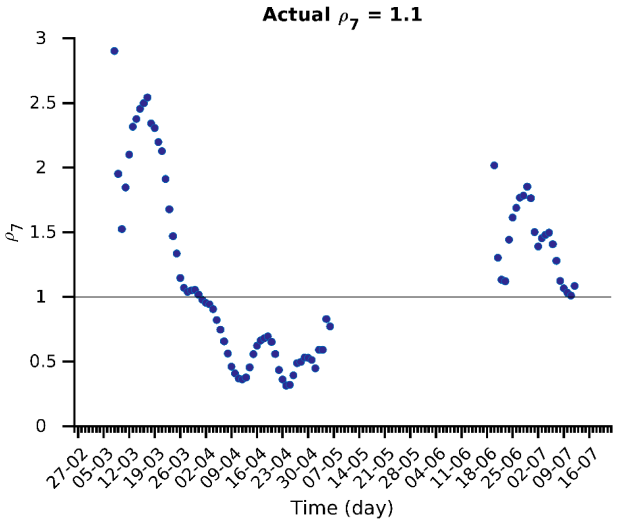
Iceland 16-07-2020. Pop: 0.3M. Cumulative incidence: 561/10⁵

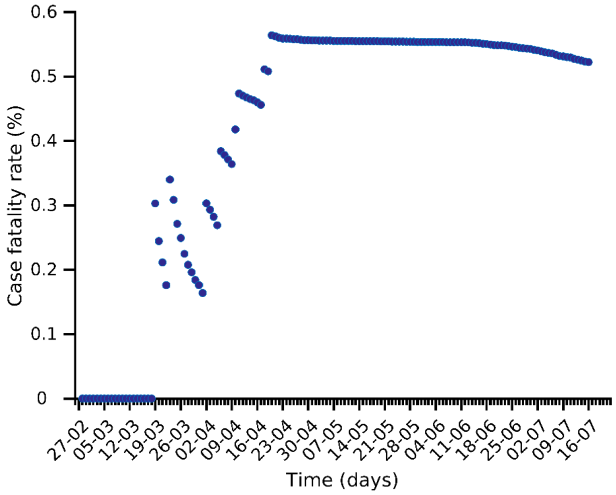


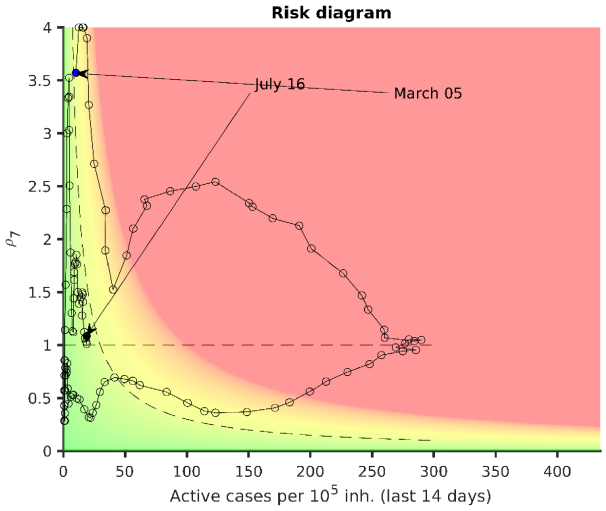


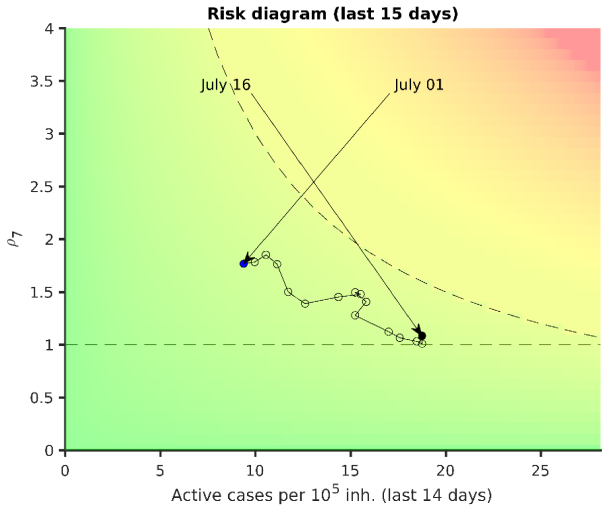




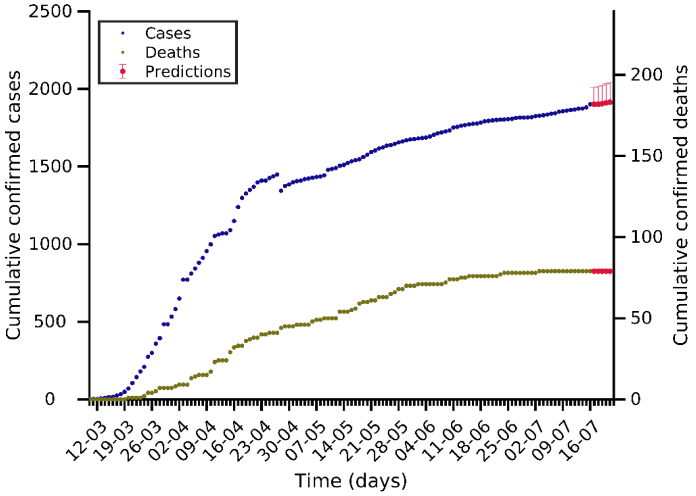


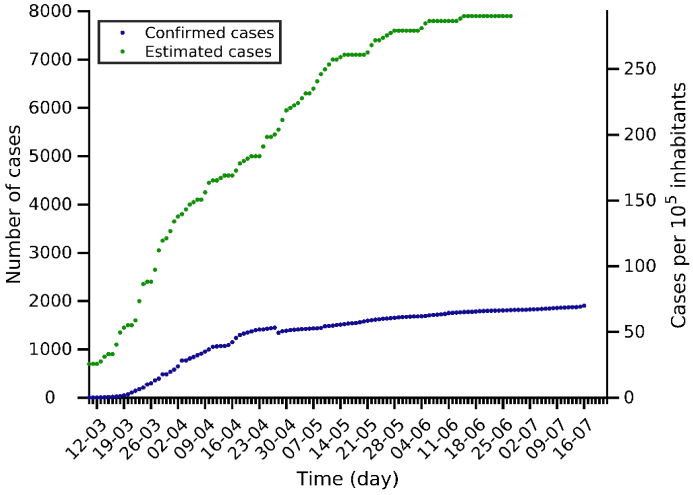


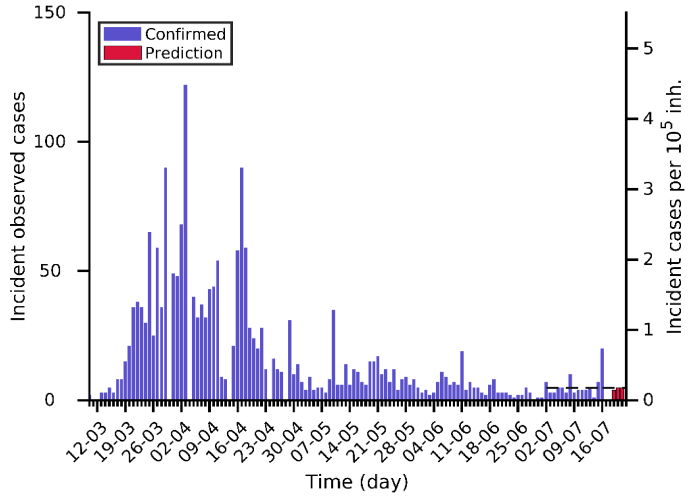


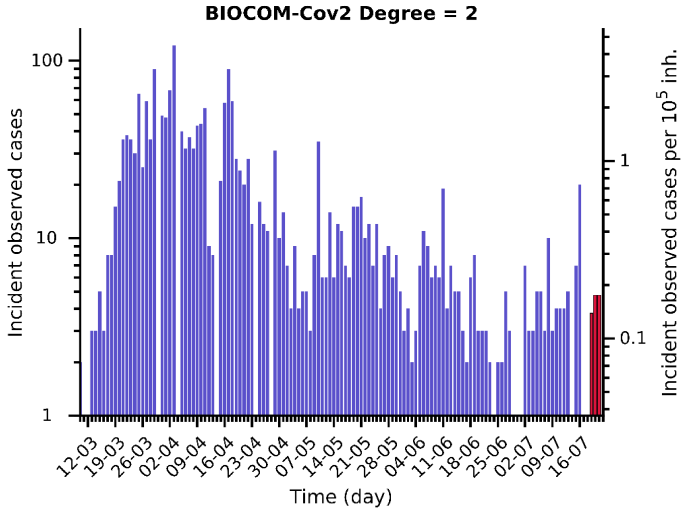


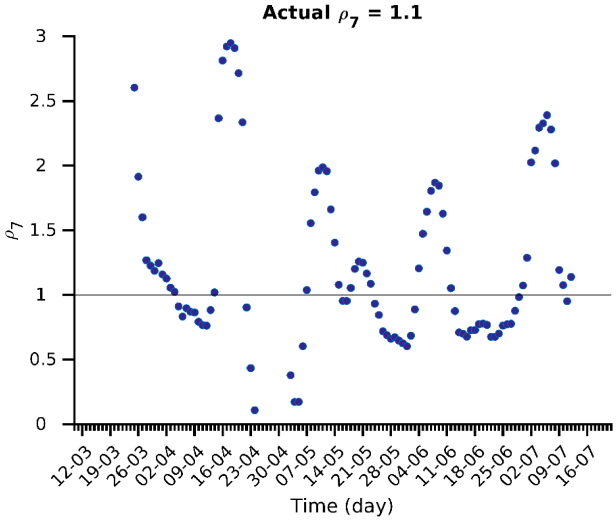
Lithuania 16-07-2020. Pop: 2.7M. Cumulative incidence: 70/10⁵

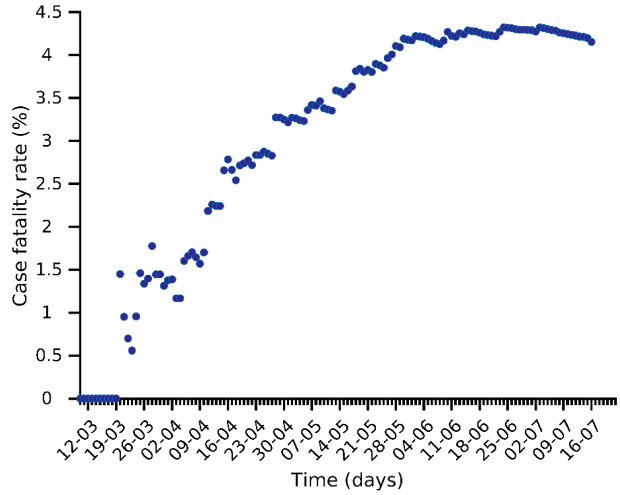


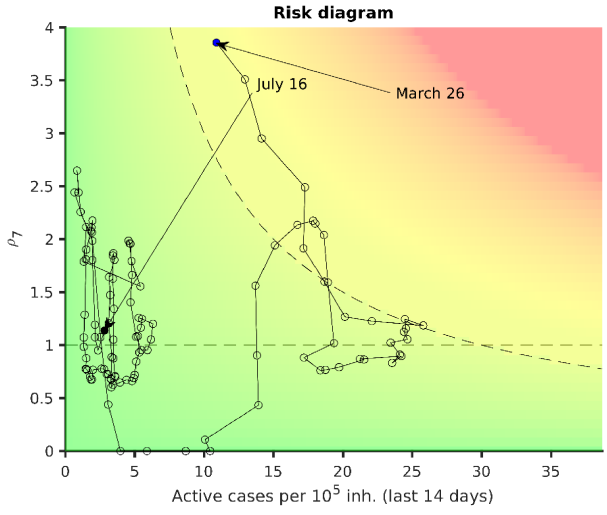


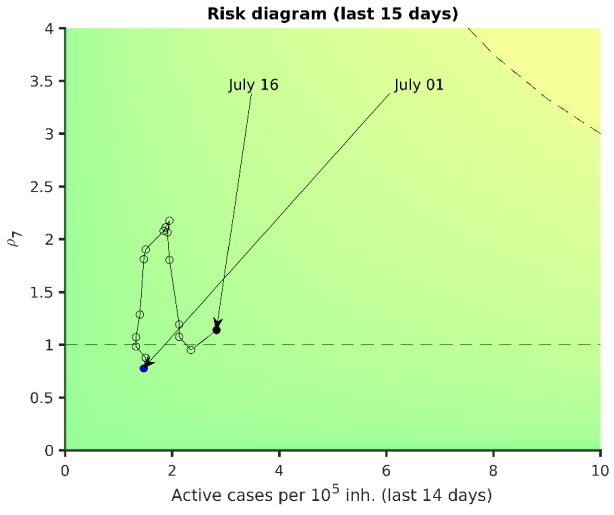




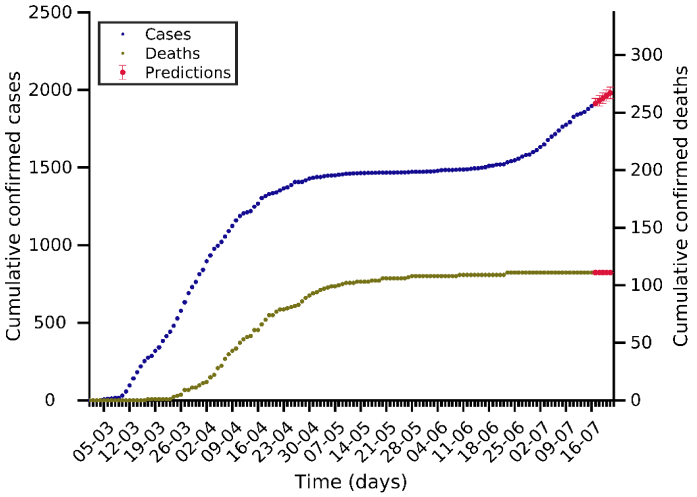


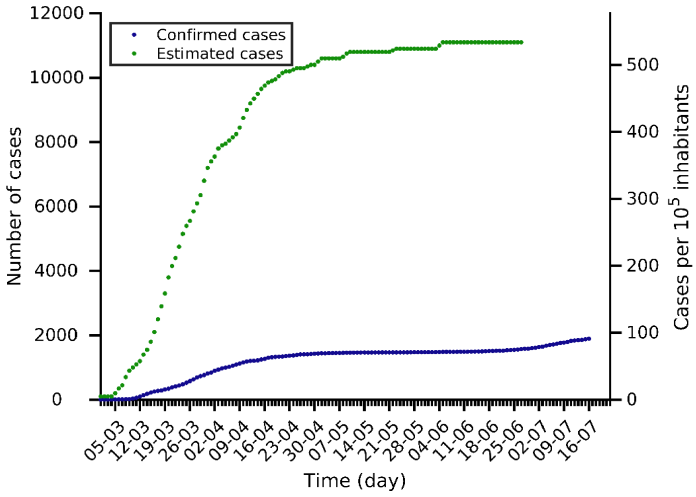


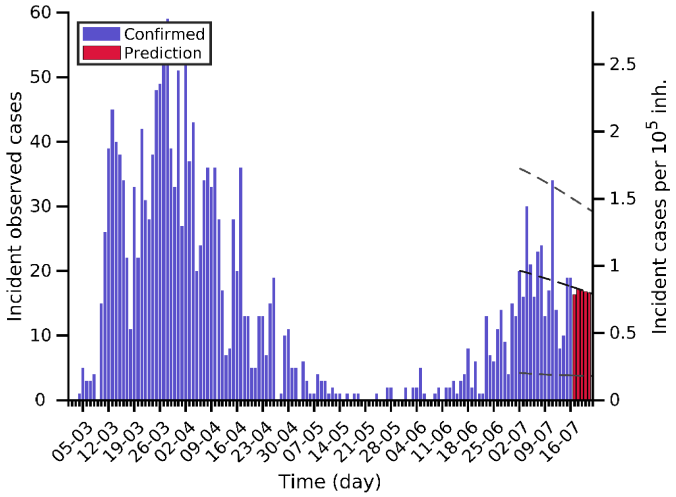


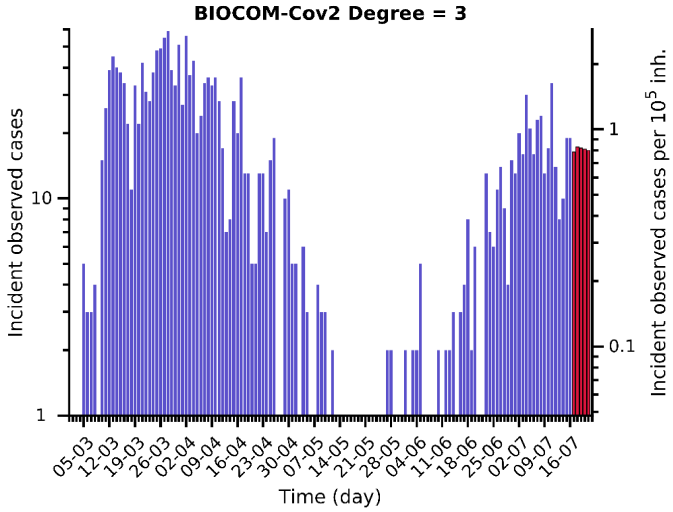


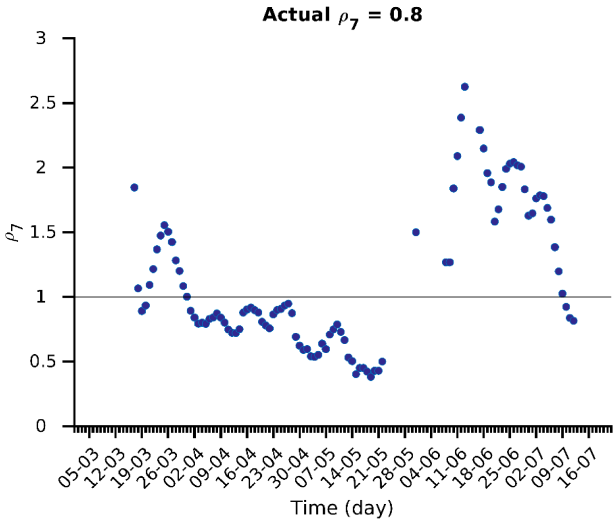
Slovenia 16-07-2020. Pop: 2.1M. Cumulative incidence: 91/10^5

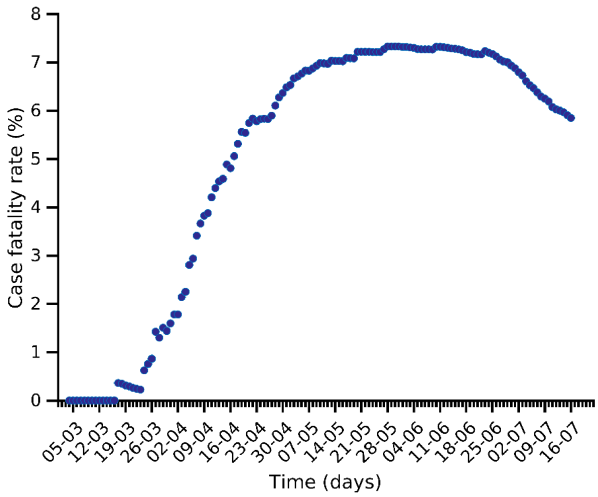


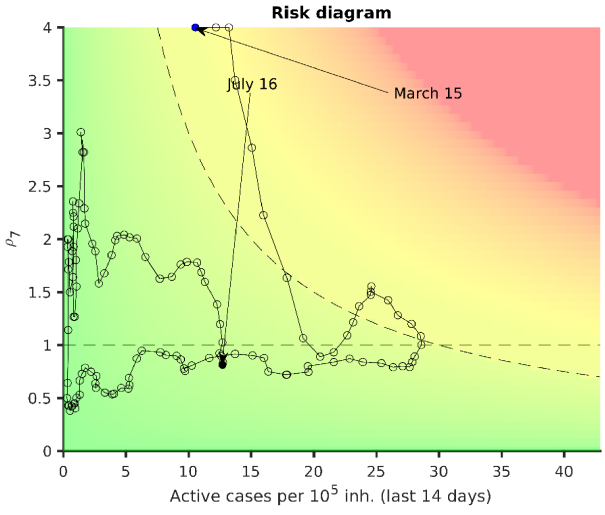


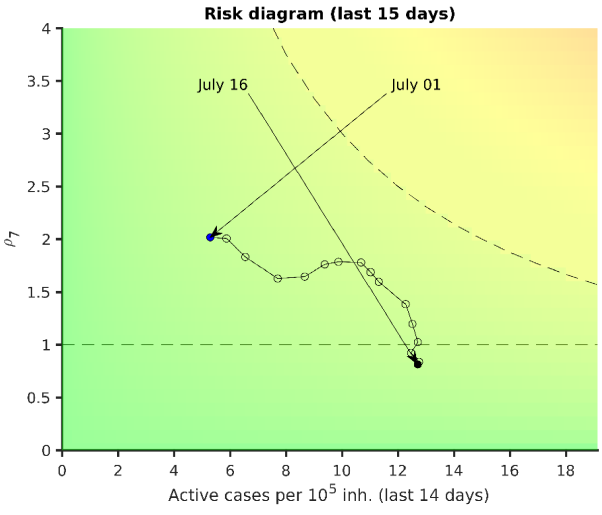




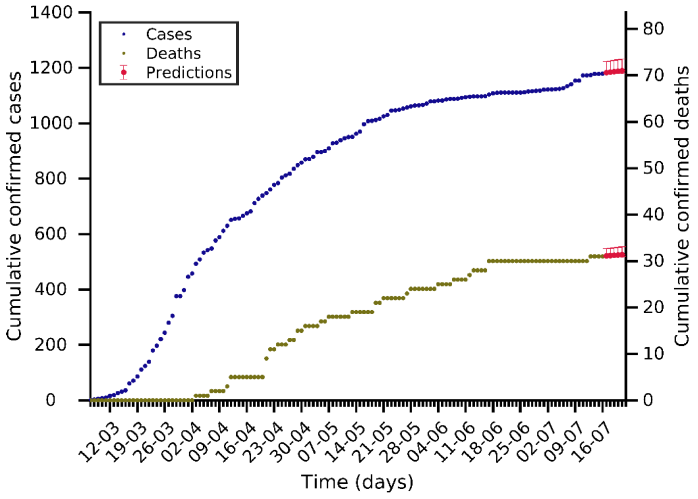


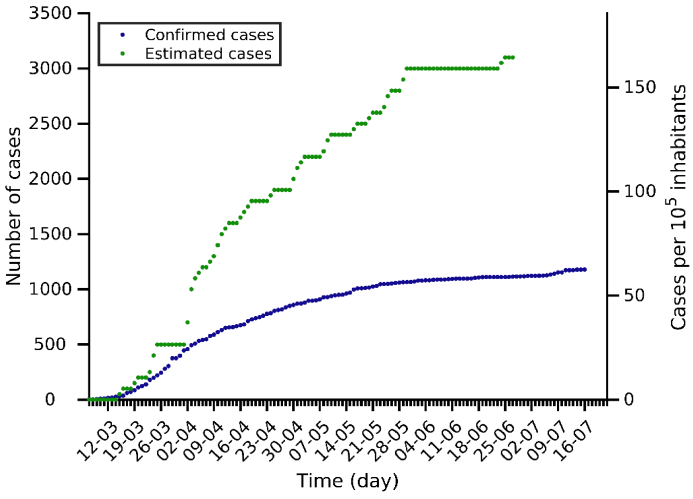


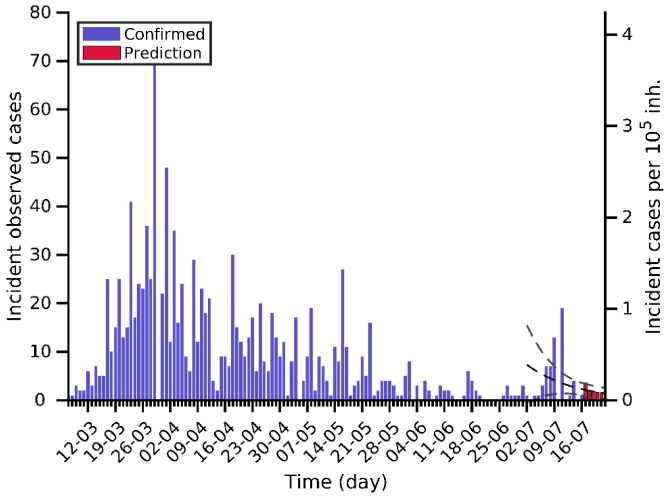


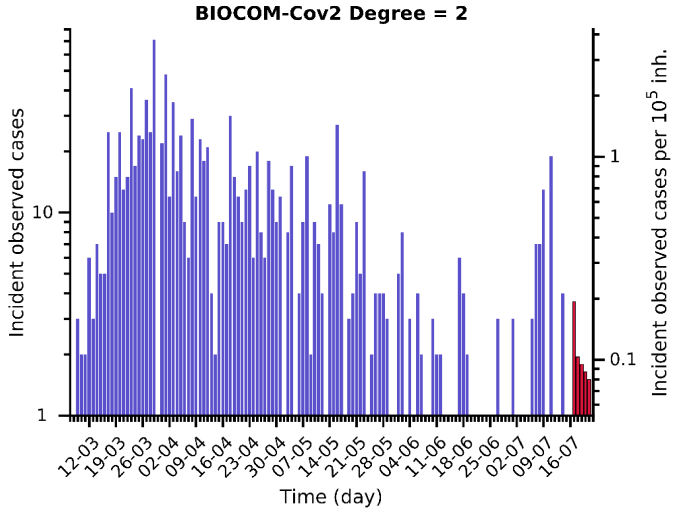


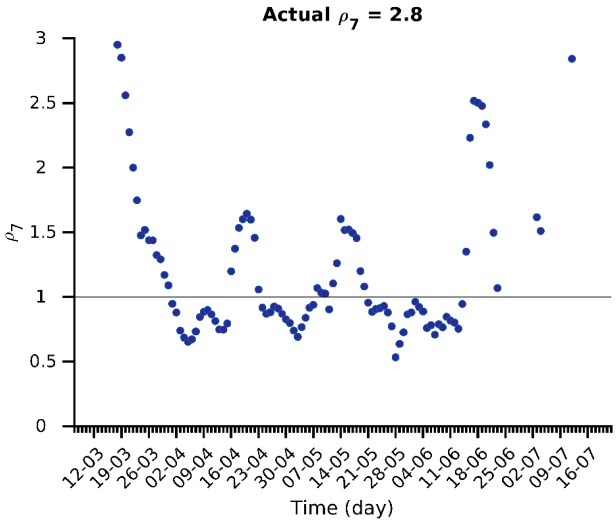
Latvia 16-07-2020. Pop: 1.9M. Cumulative incidence: 63/10^5

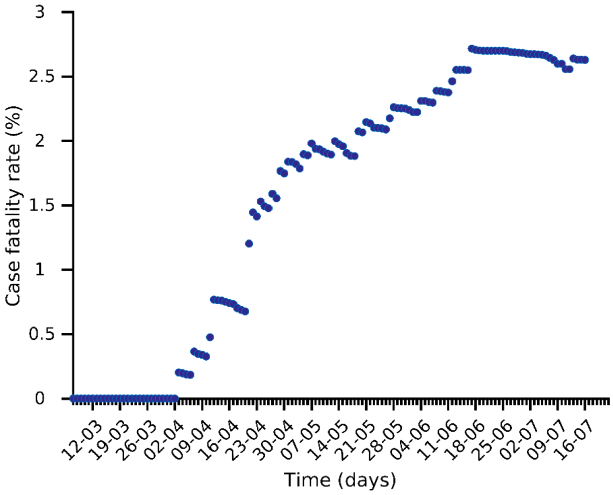


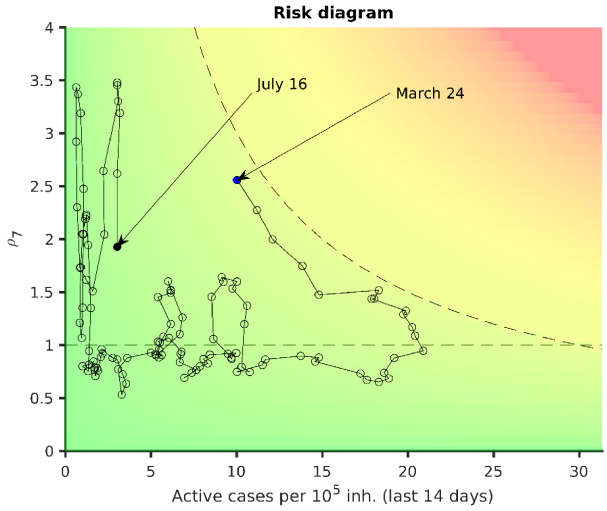


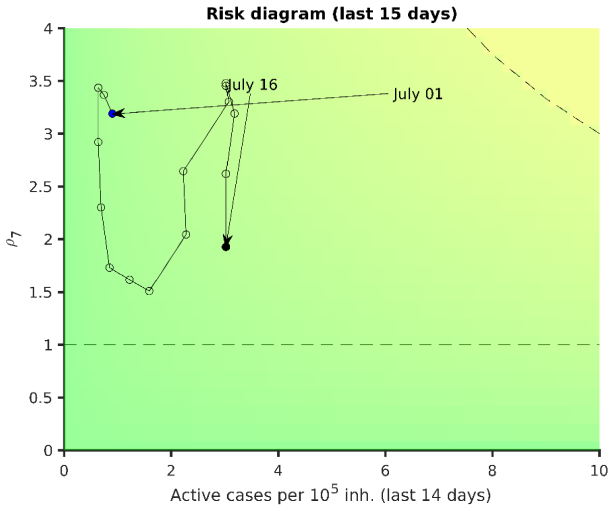




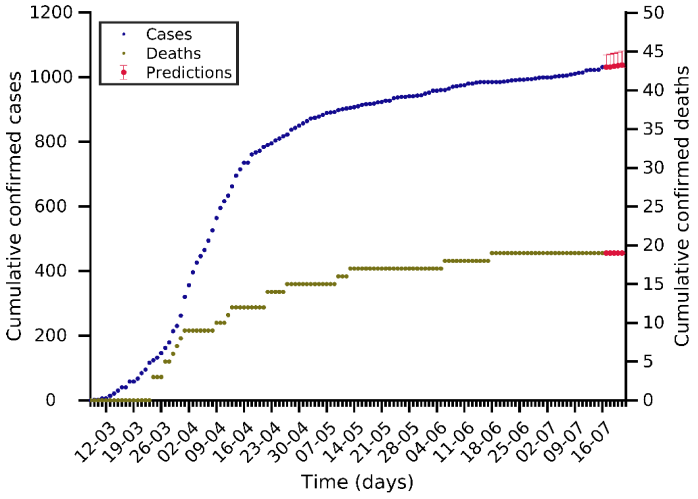


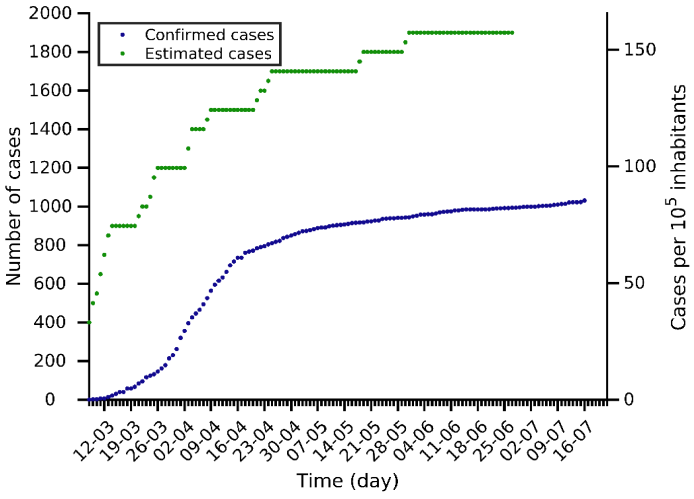


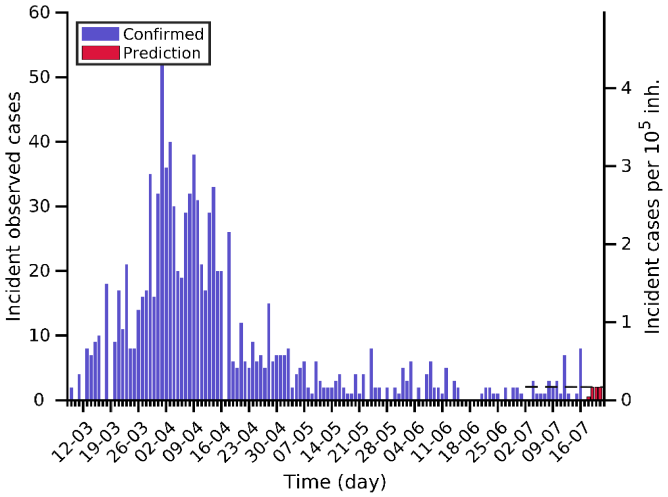


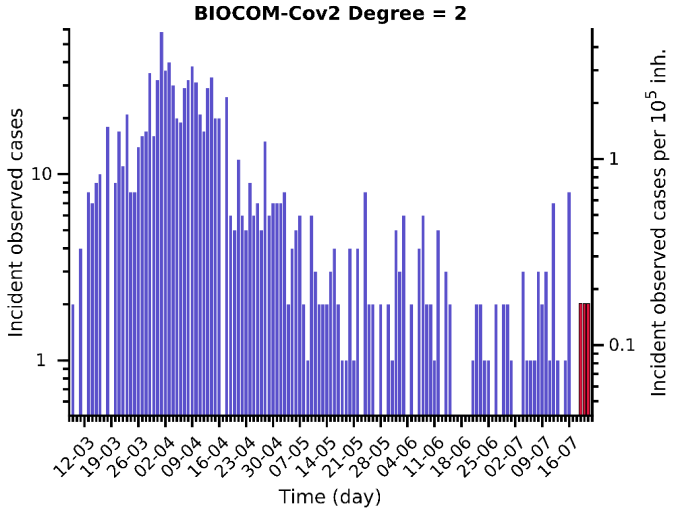


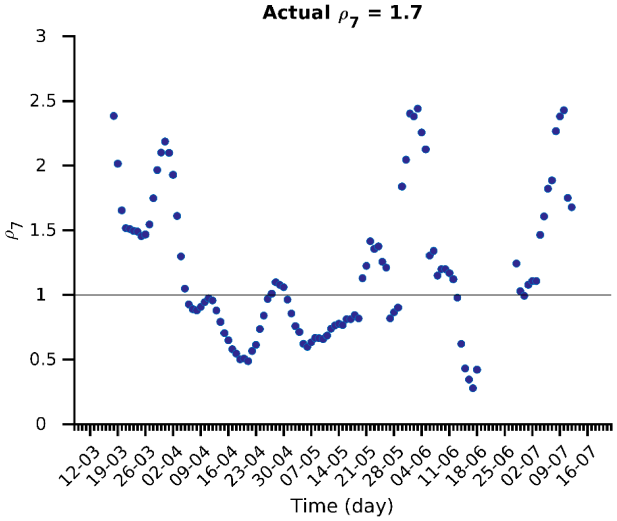
Cyprus 16-07-2020. Pop: 1.2M. Cumulative incidence: 85/10⁵

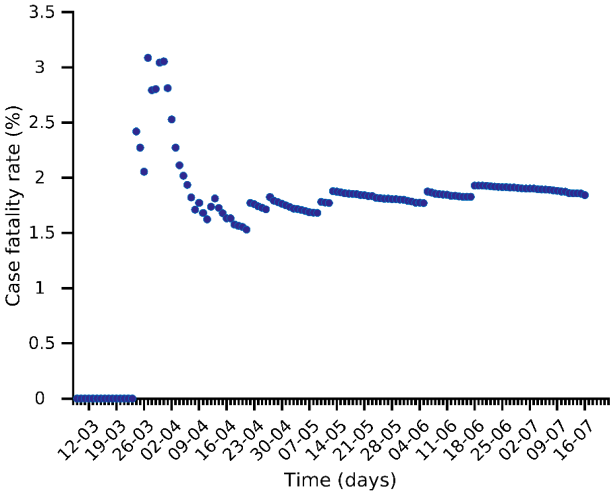


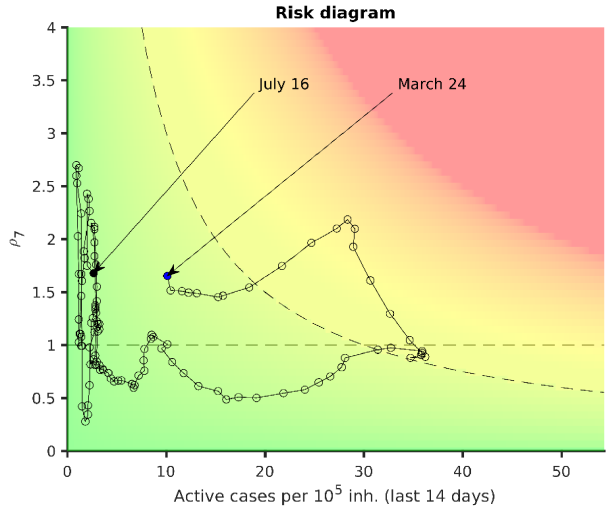


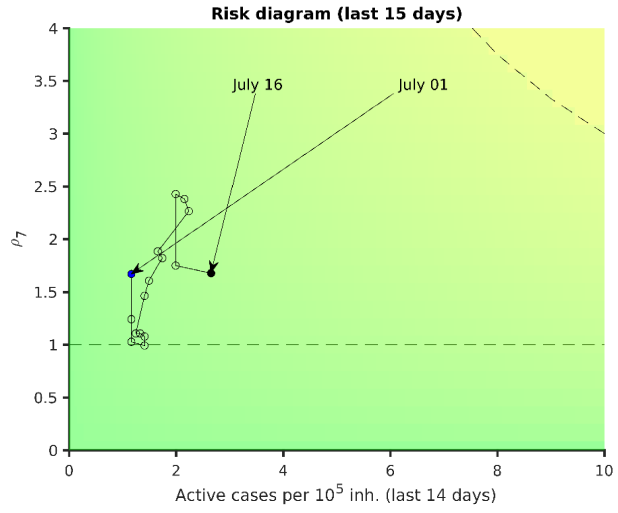




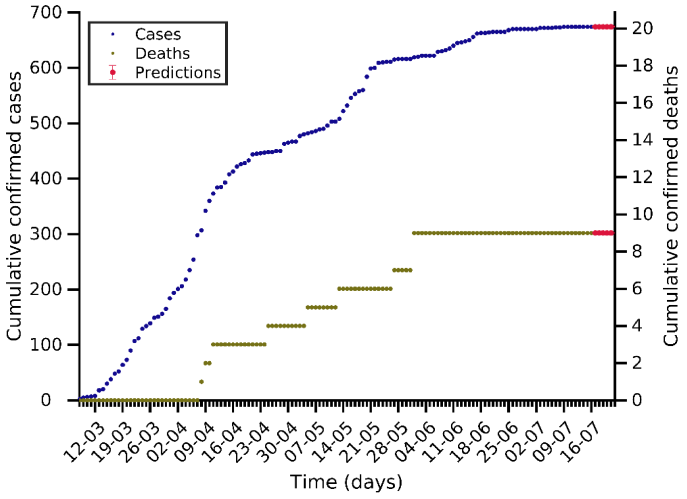


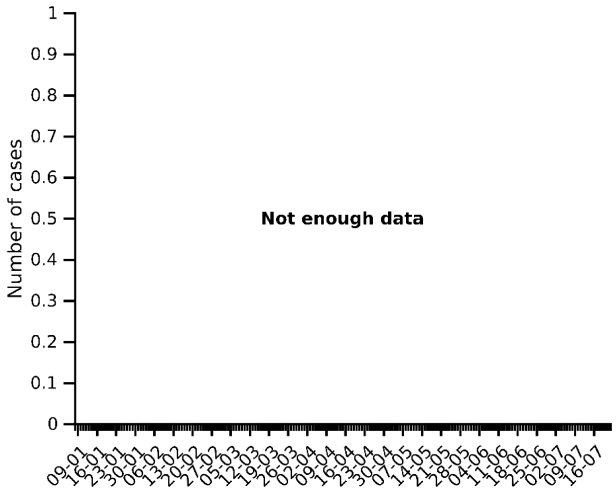


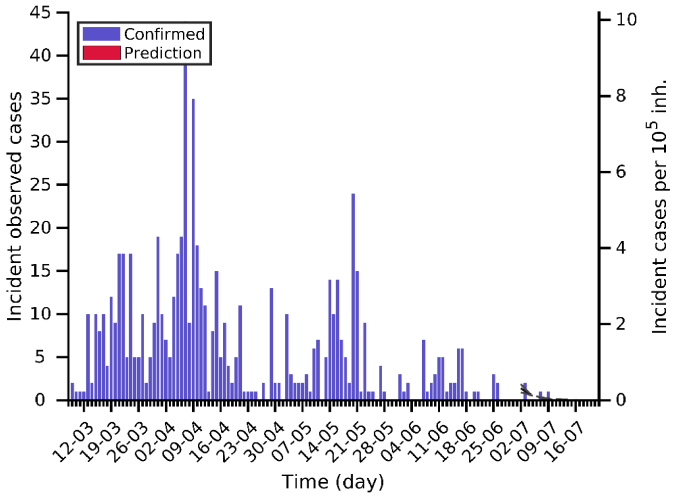


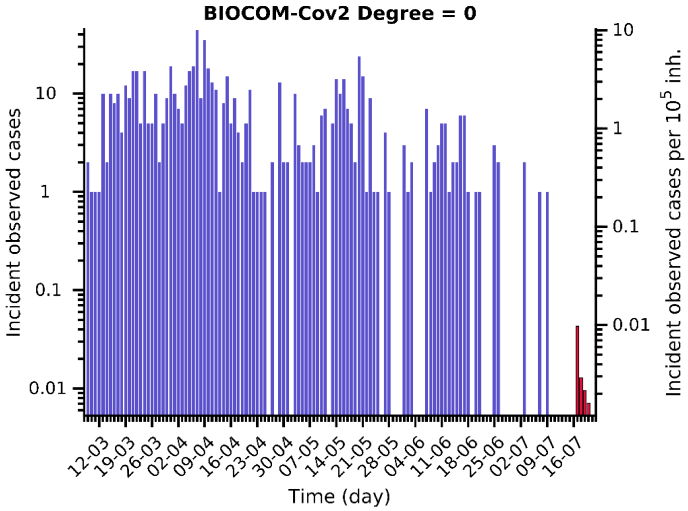


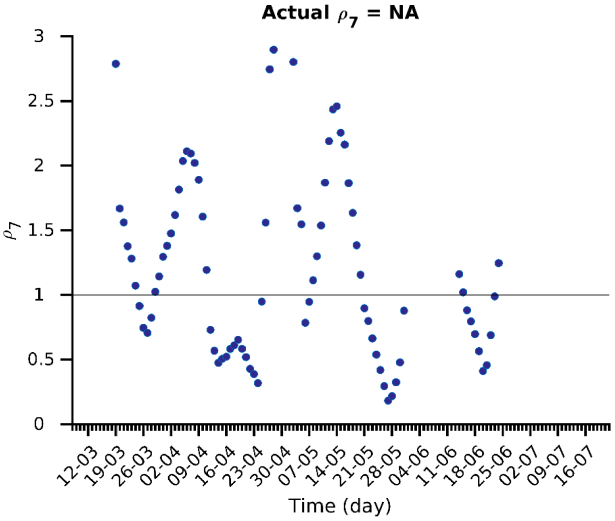
Malta 16-07-2020. Pop: 0.4M. Cumulative incidence: 153/10⁵

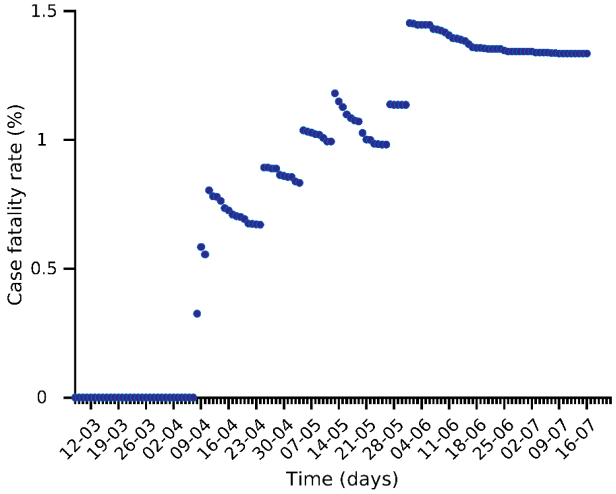


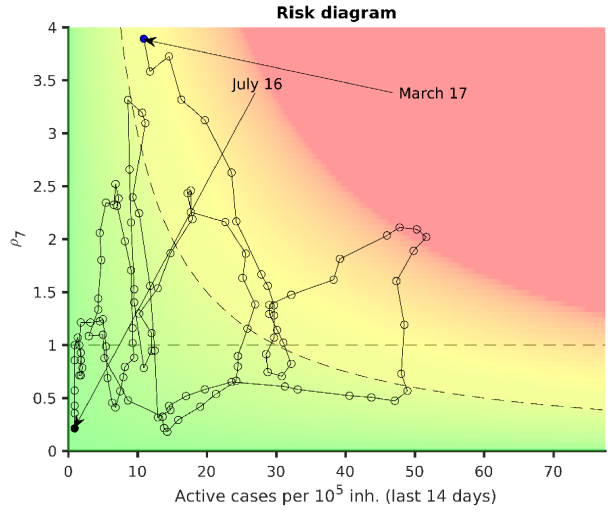


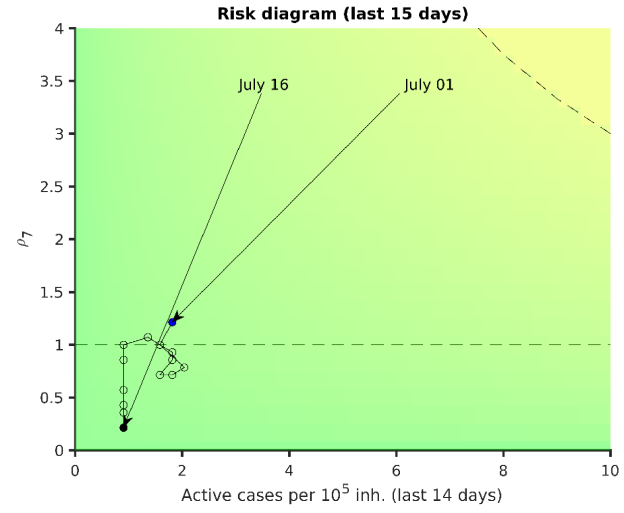








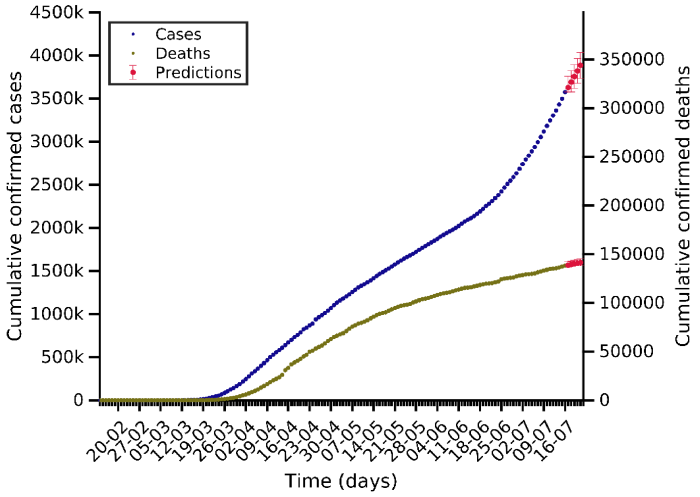


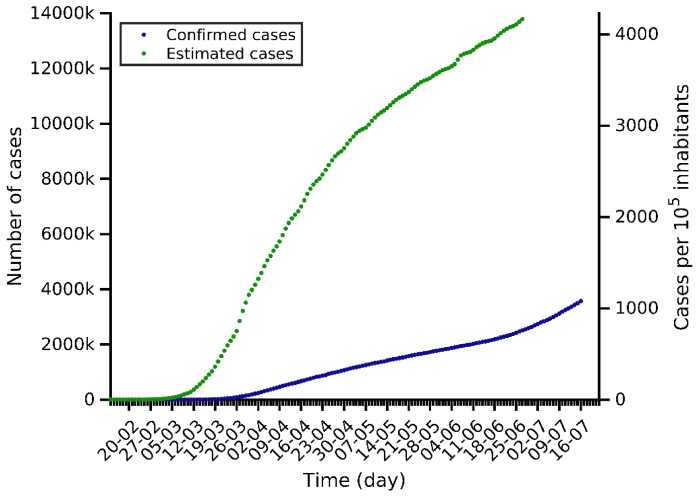


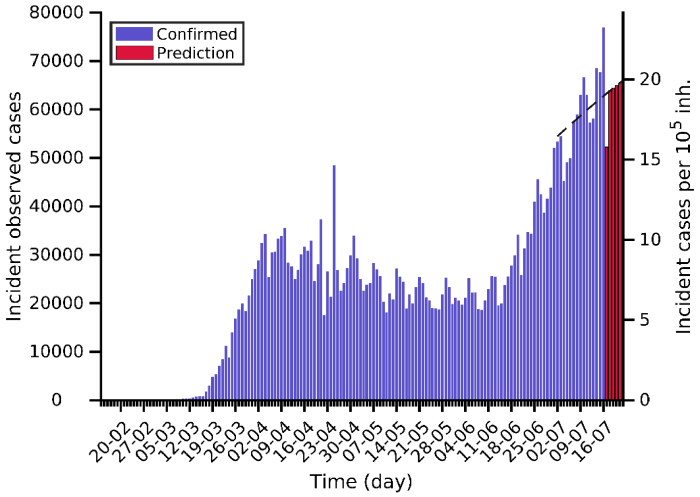
(2) Analysis and prediction of COVID-19 for other countries

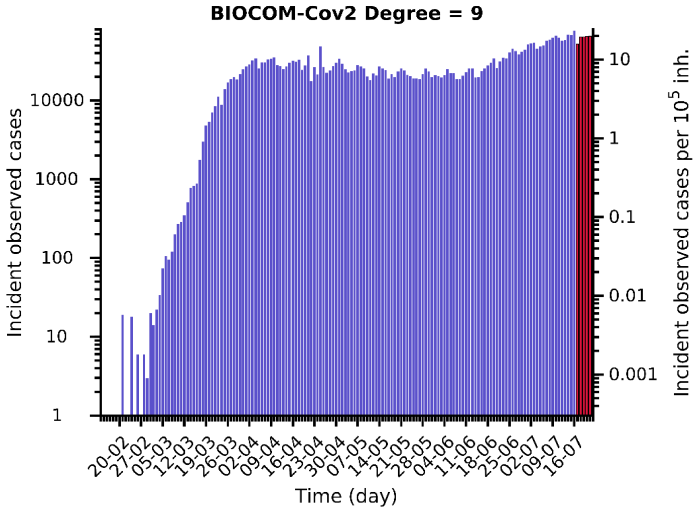
Data obtained from https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

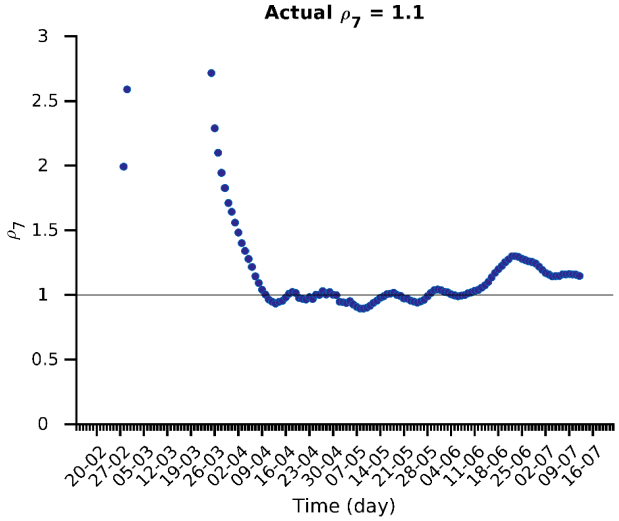
USA 16-07-2020. Pop: 331.0M. Cumulative incidence: 1080/10⁵

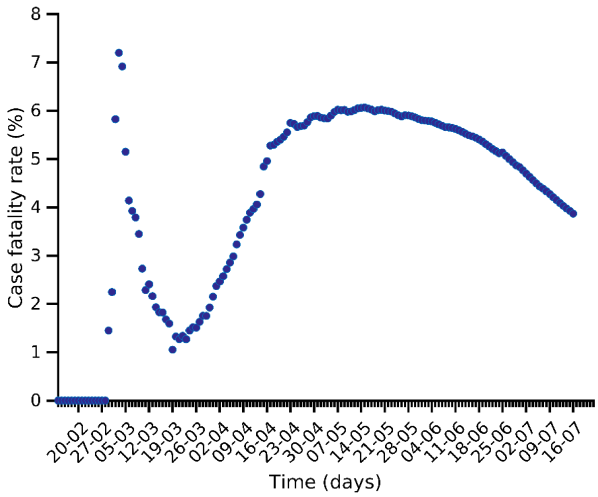


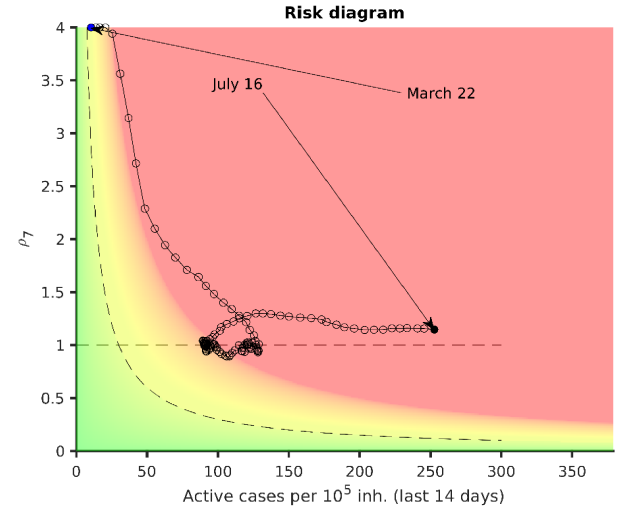


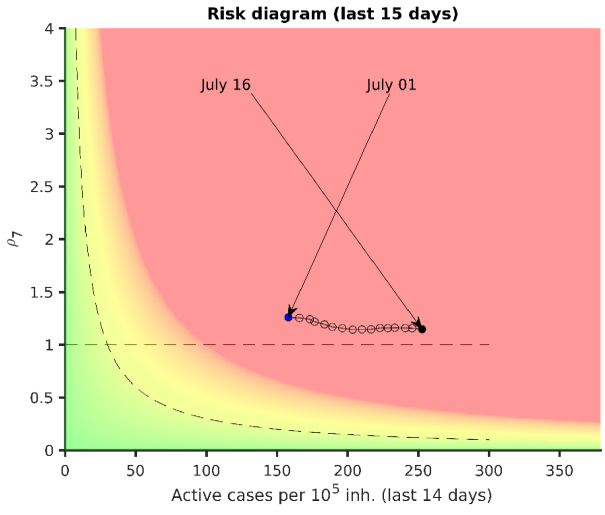




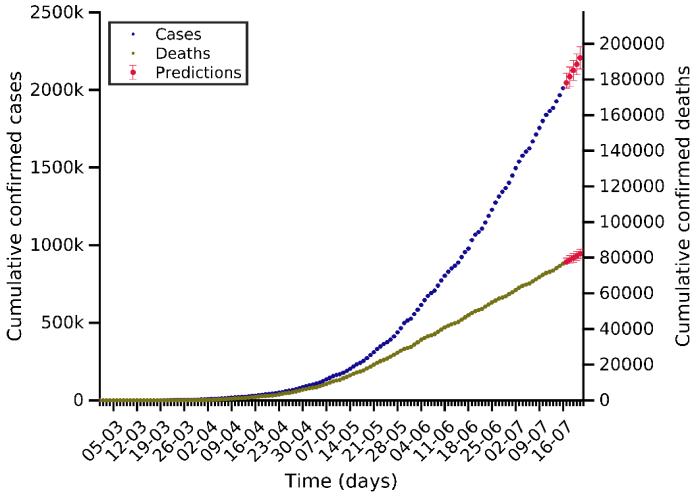


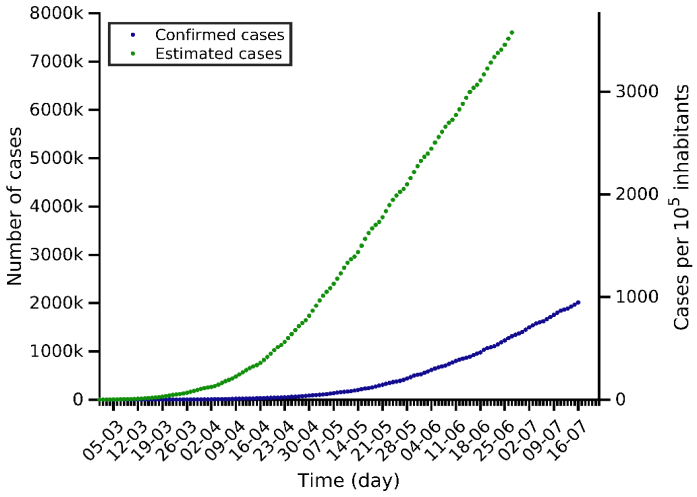


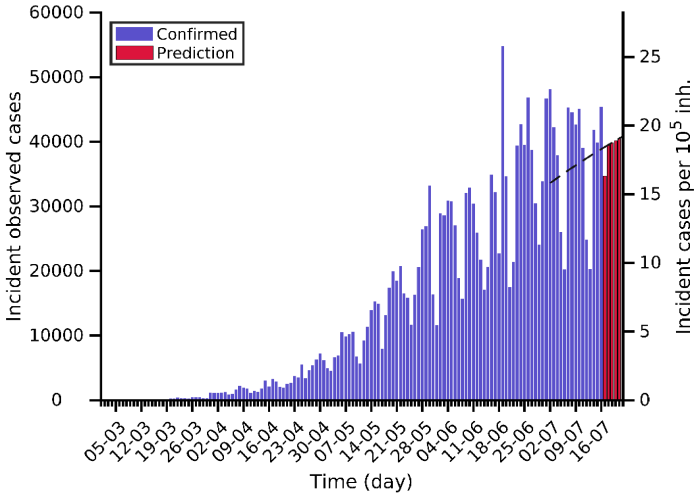


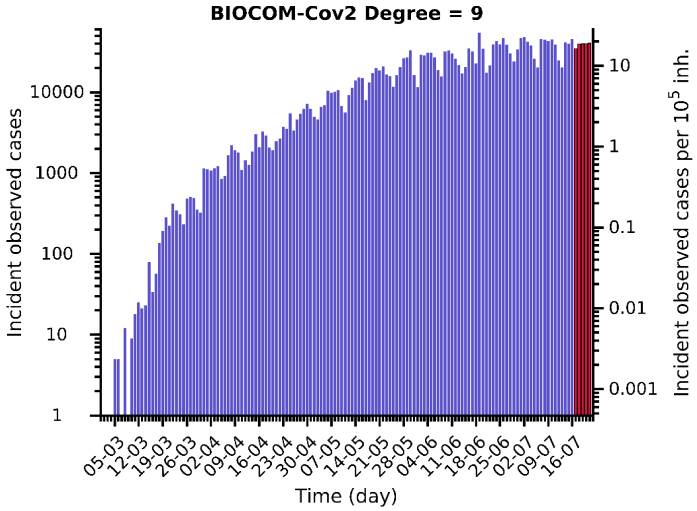


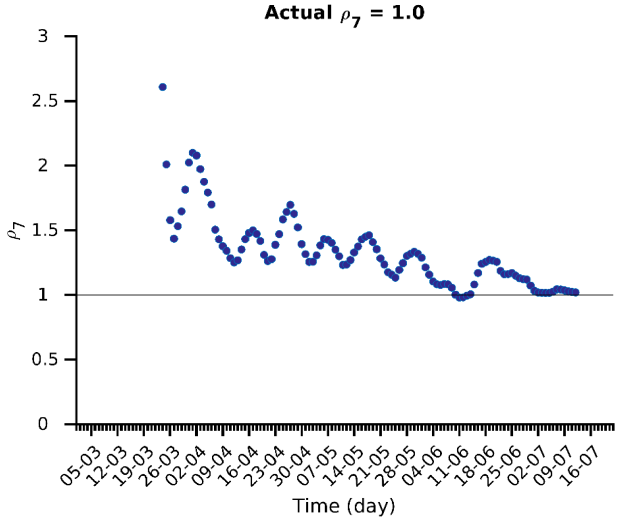
Brazil 16-07-2020. Pop: 212.6M. Cumulative incidence: 947/10⁵

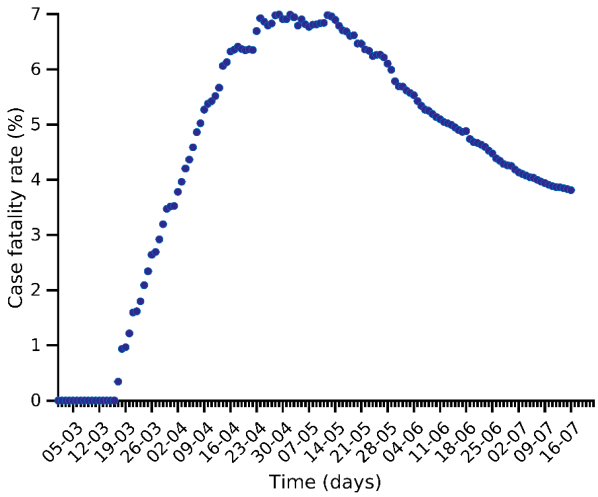


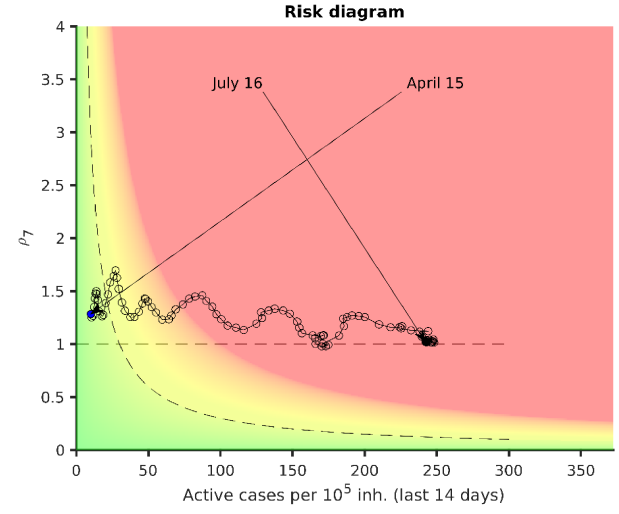


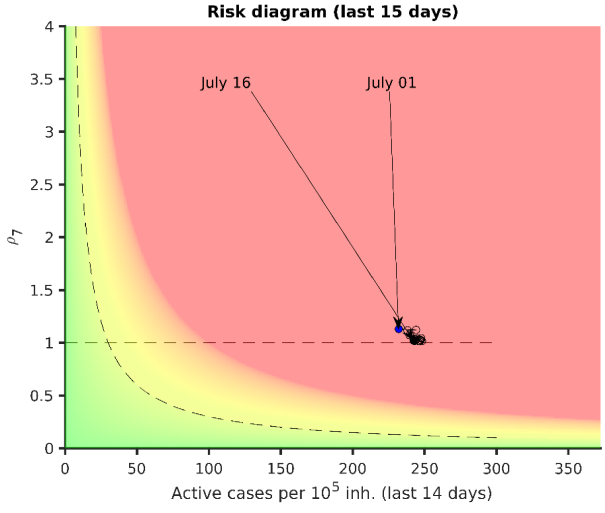




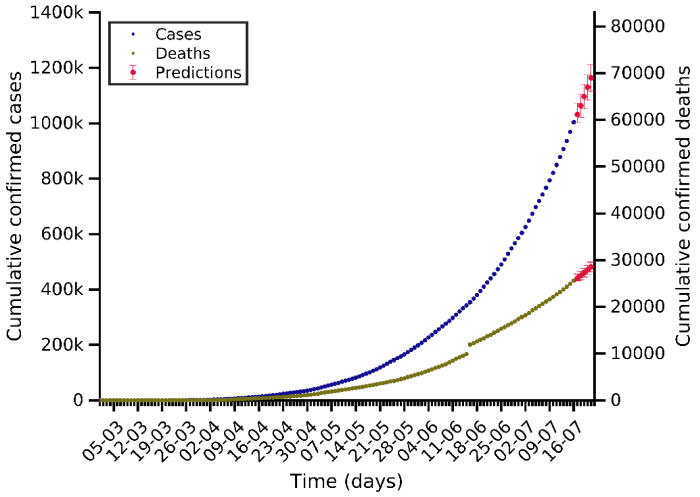


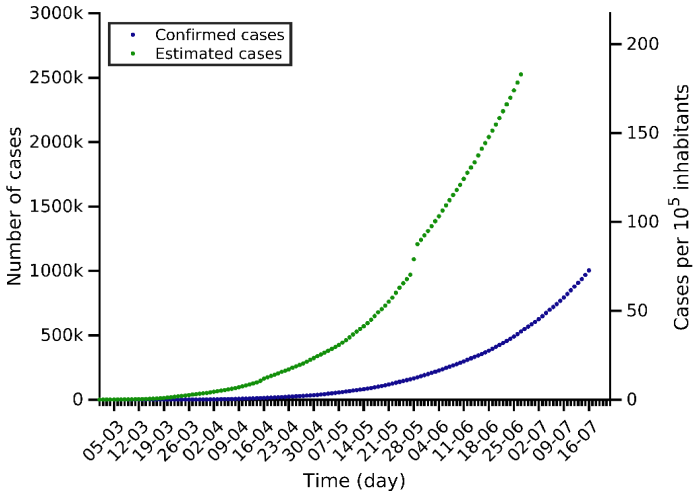


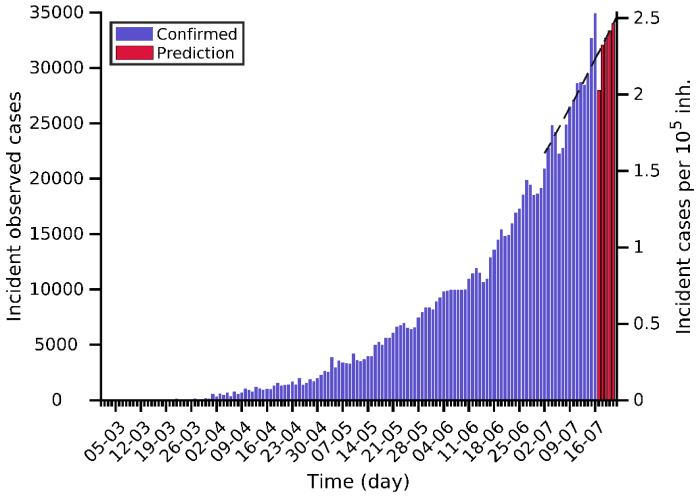


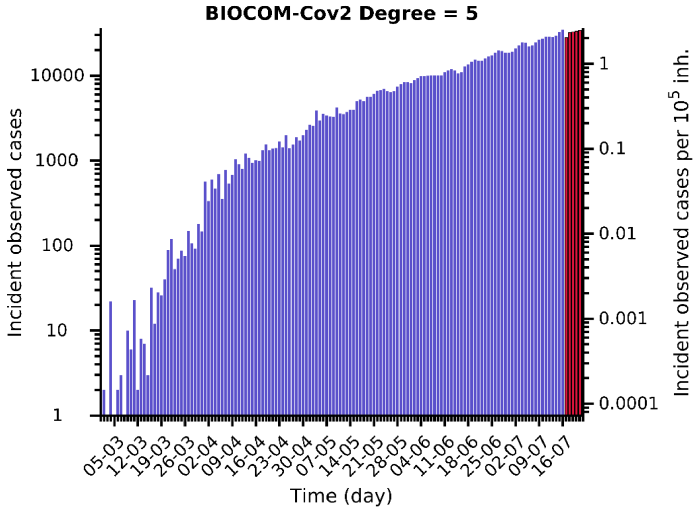


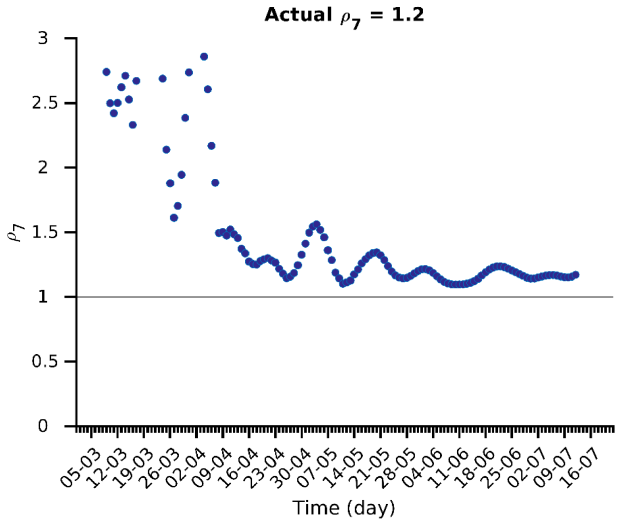
India 16-07-2020. Pop: 1380.0M. Cumulative incidence: 73/10⁵

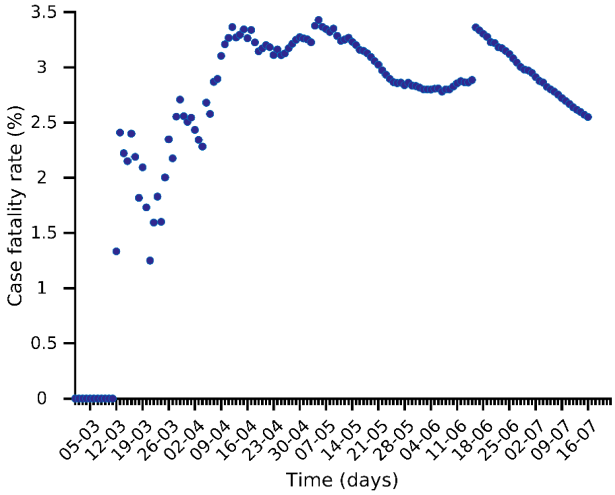


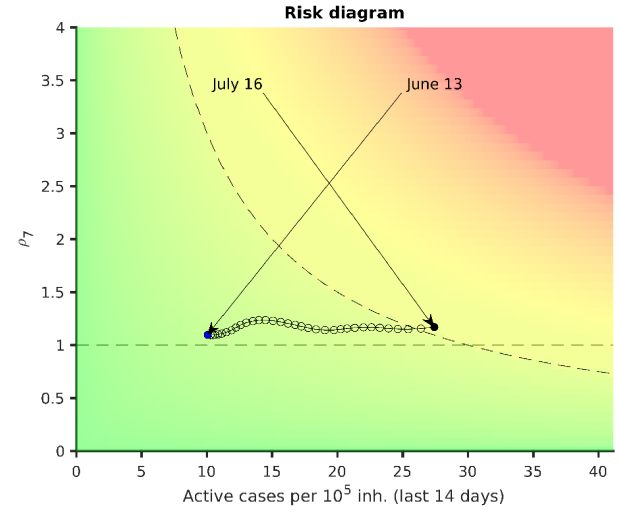


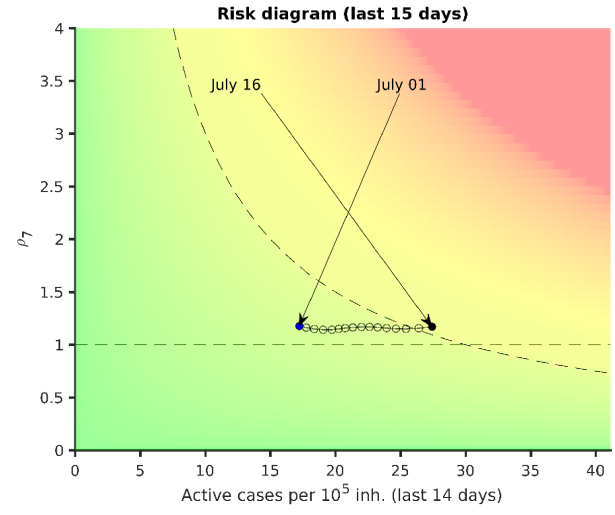




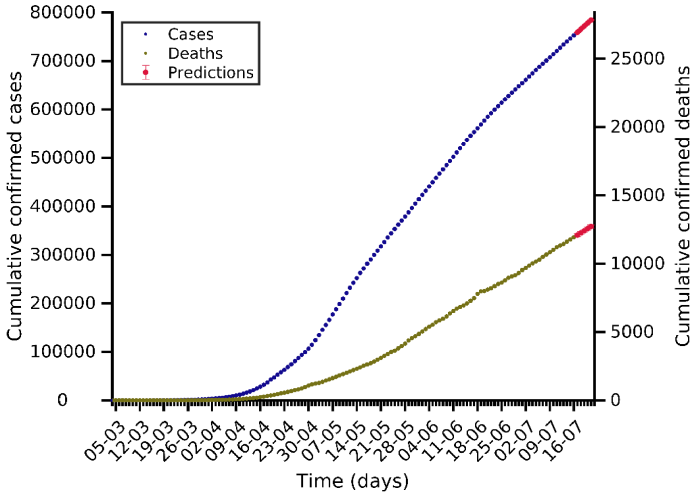


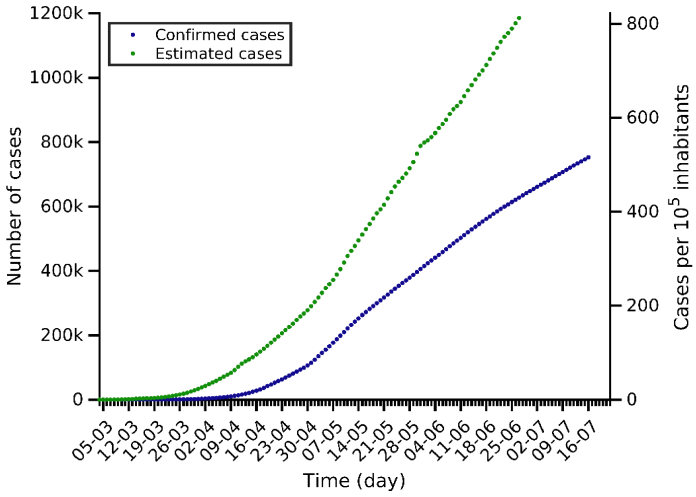


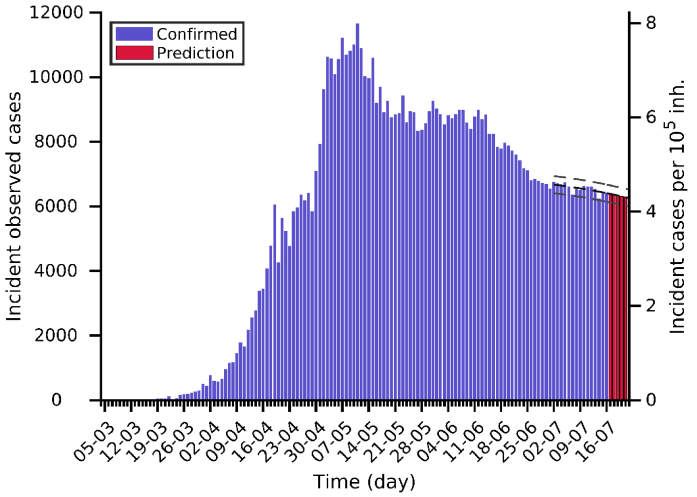


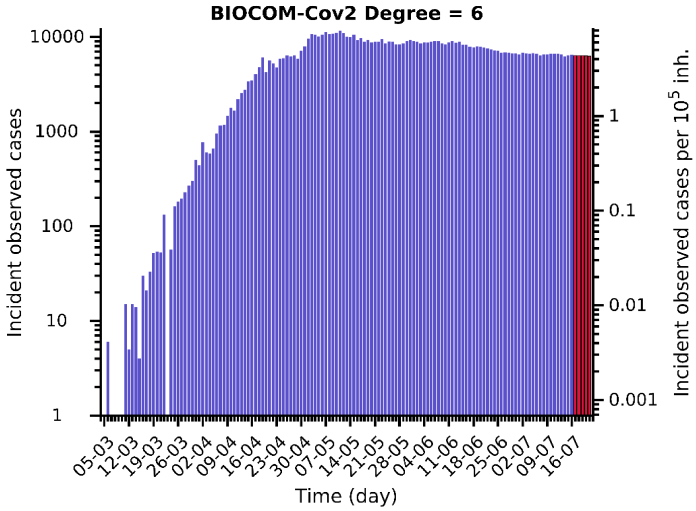


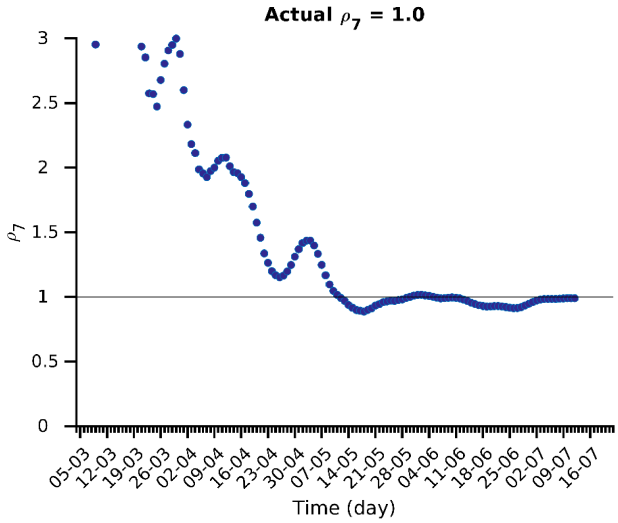
Russia 16-07-2020. Pop: 145.9M. Cumulative incidence: 516/10⁵

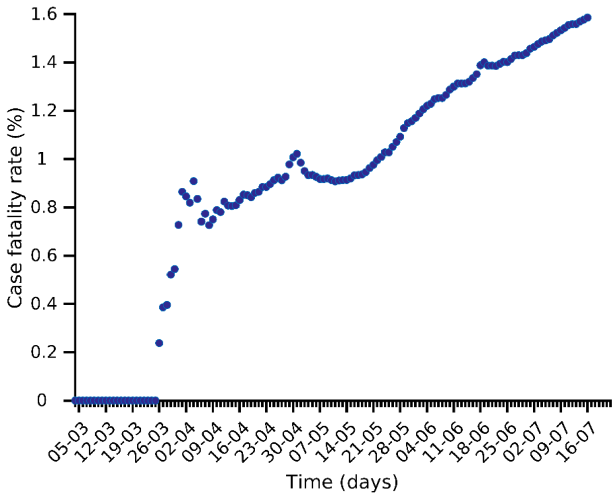


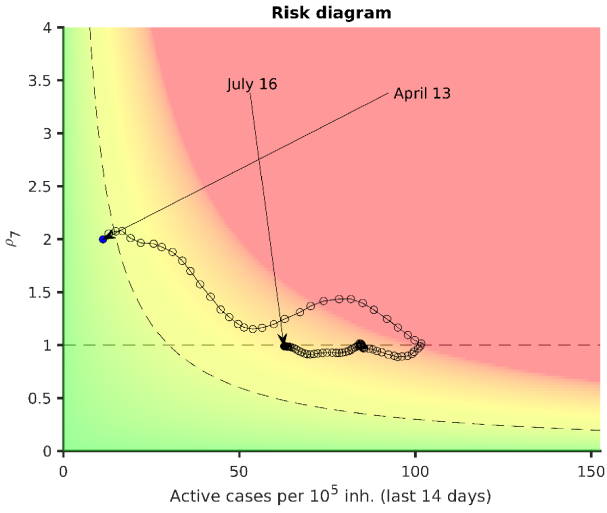


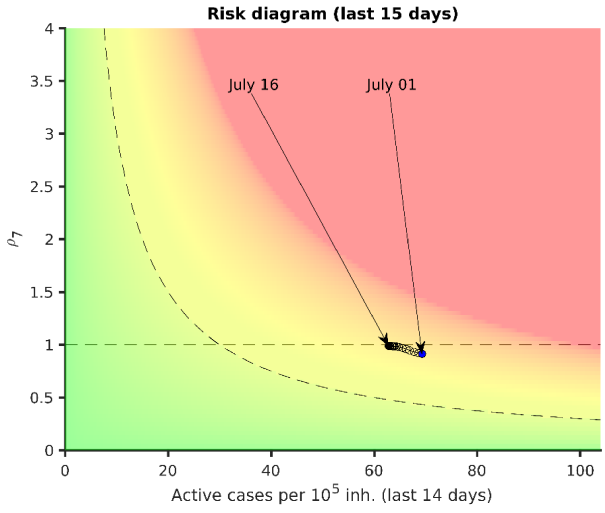




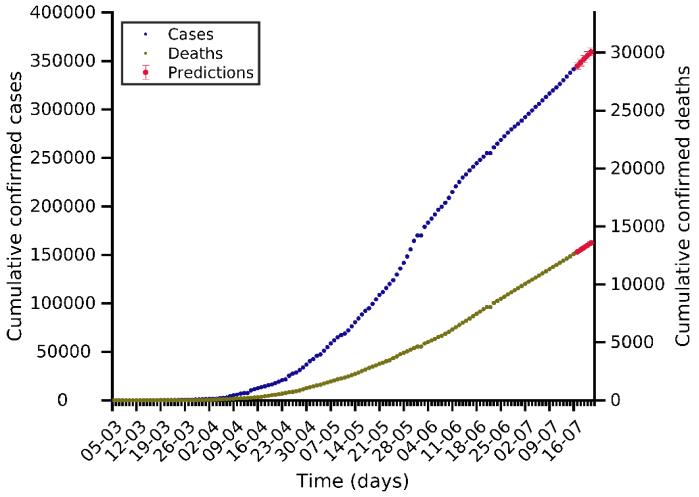


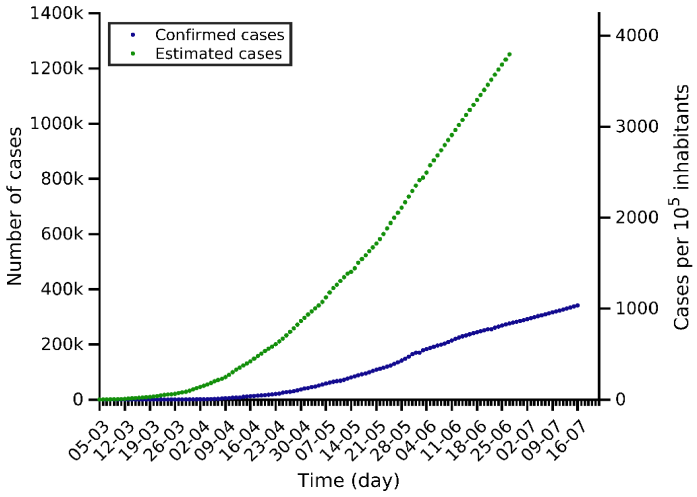


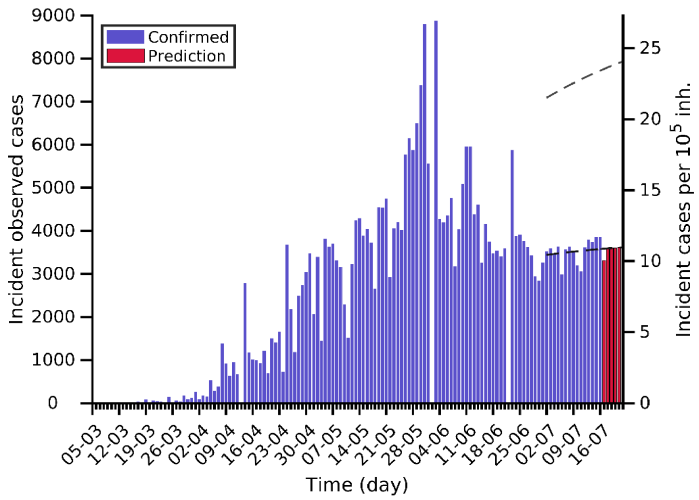


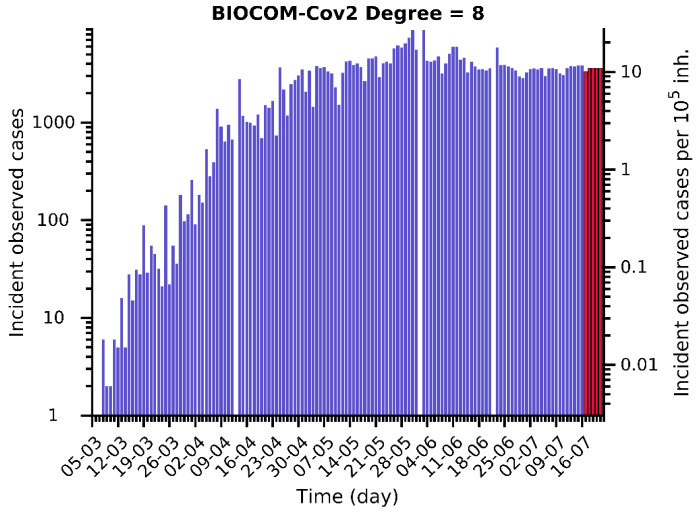


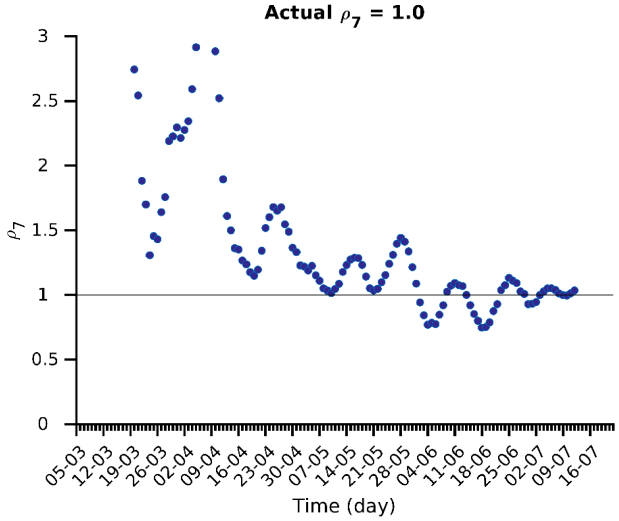
Peru 16-07-2020. Pop: 33.0M. Cumulative incidence: 1036/10⁵

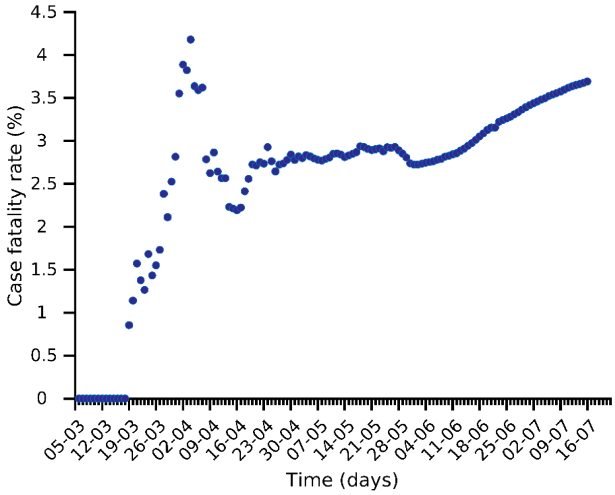


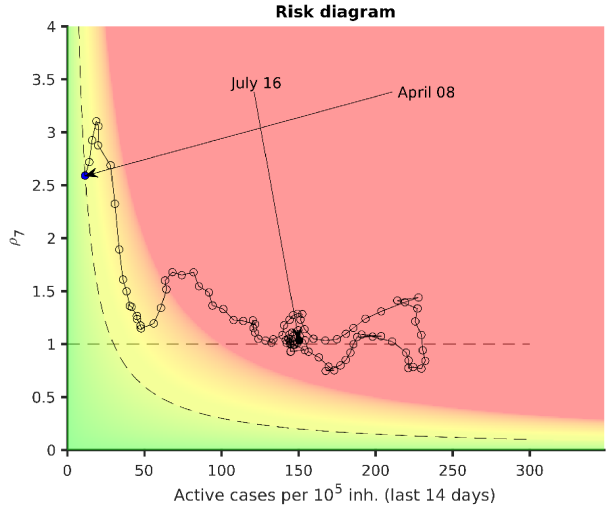


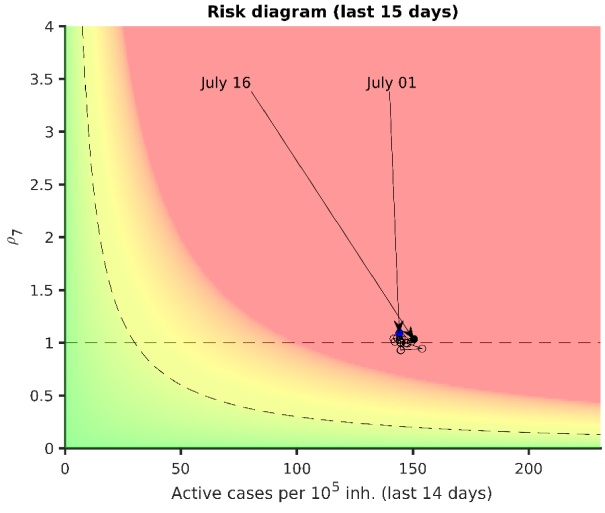




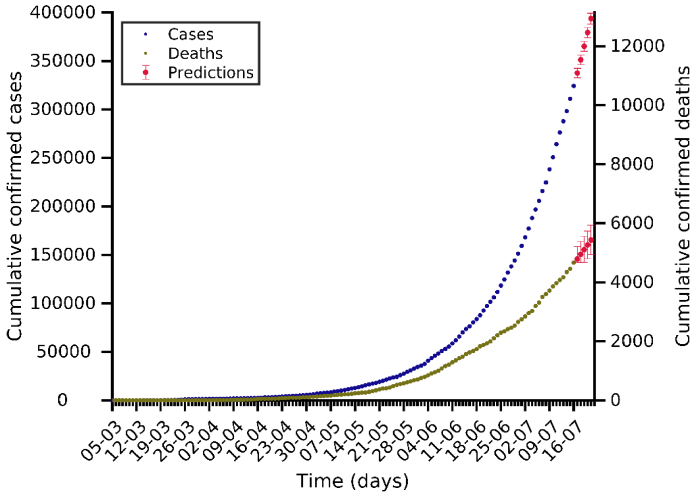


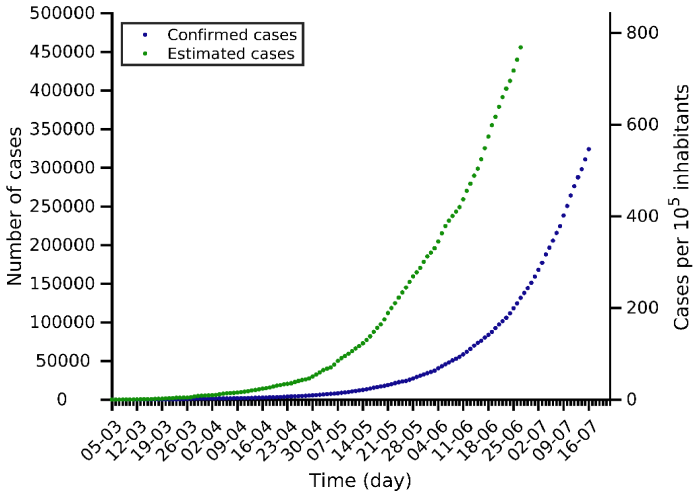


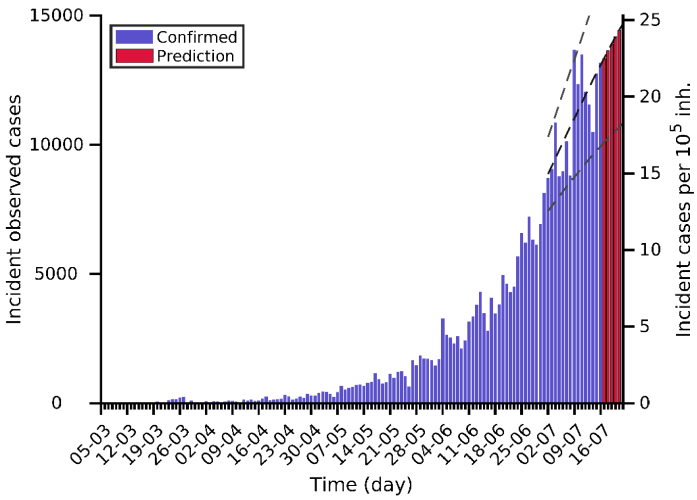


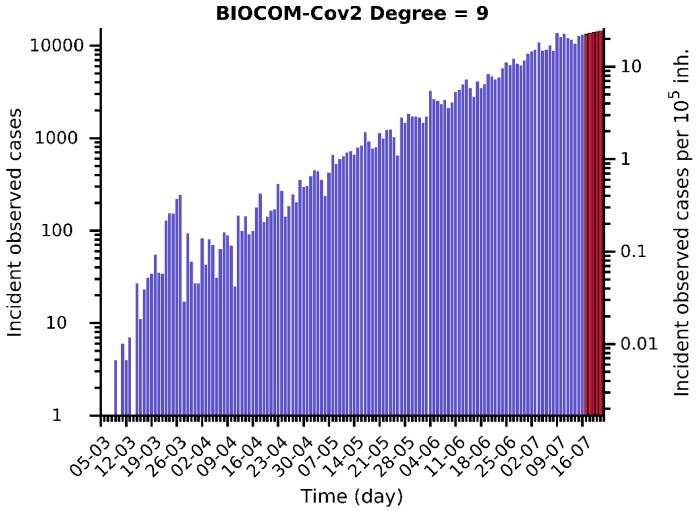


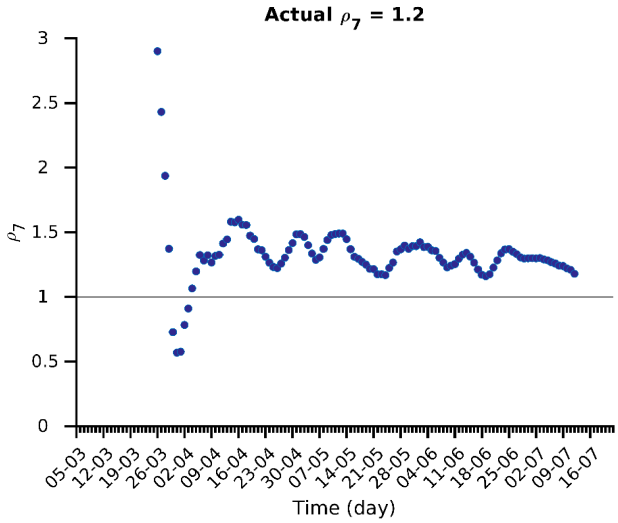
South Africa 16-07-2020. Pop: 59.3M. Cumulative incidence: 547/10⁵

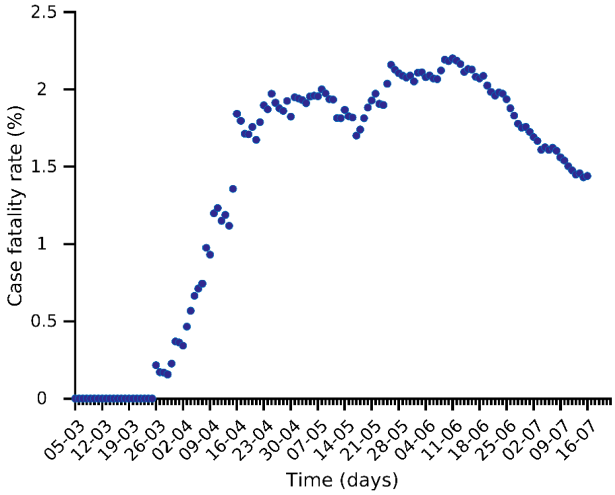


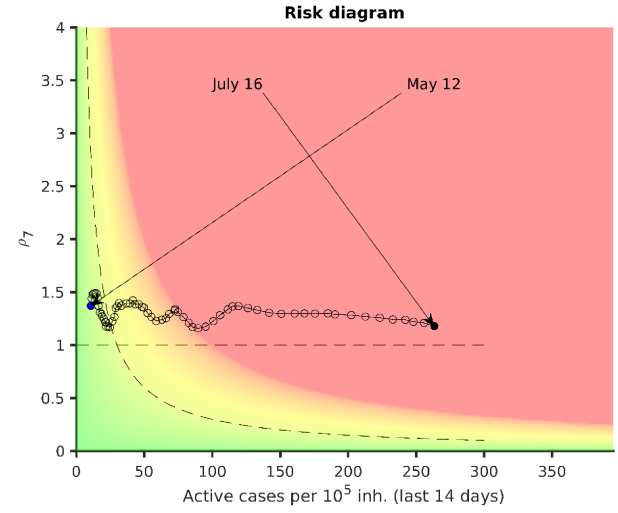


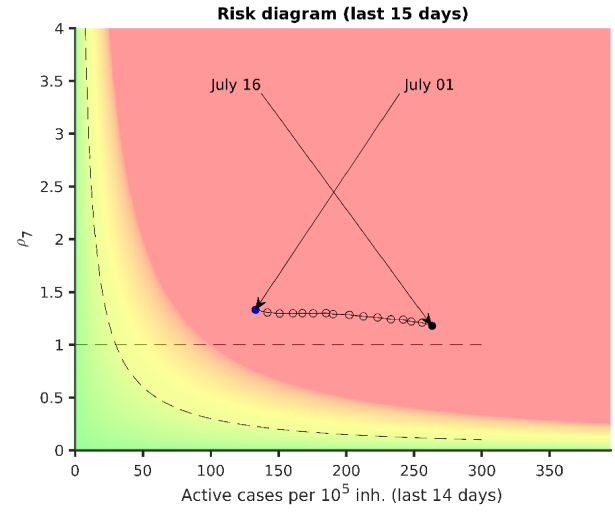




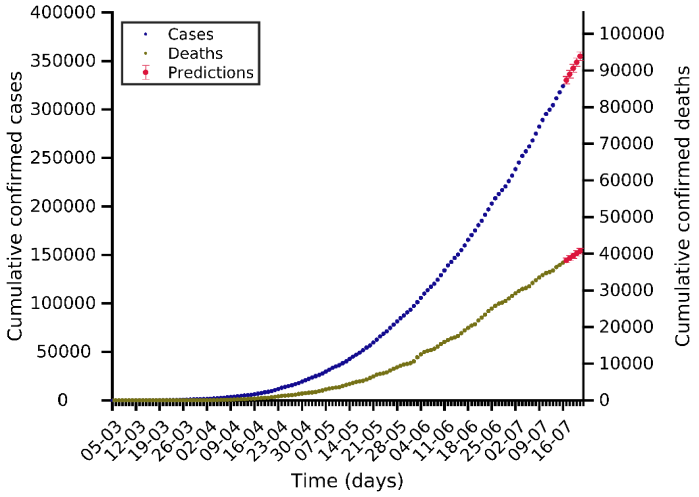


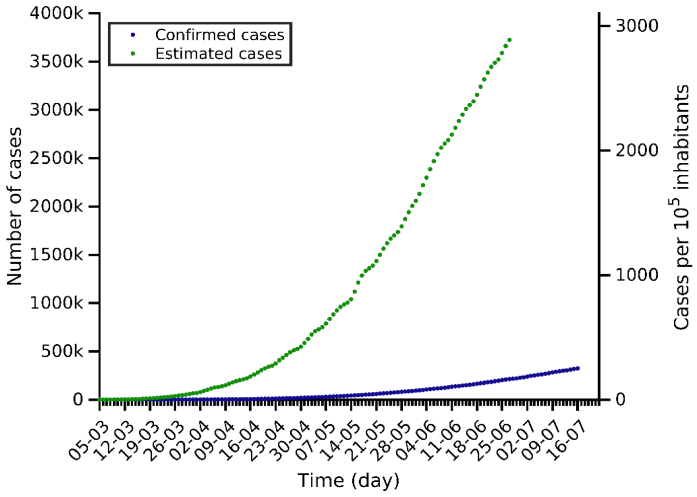


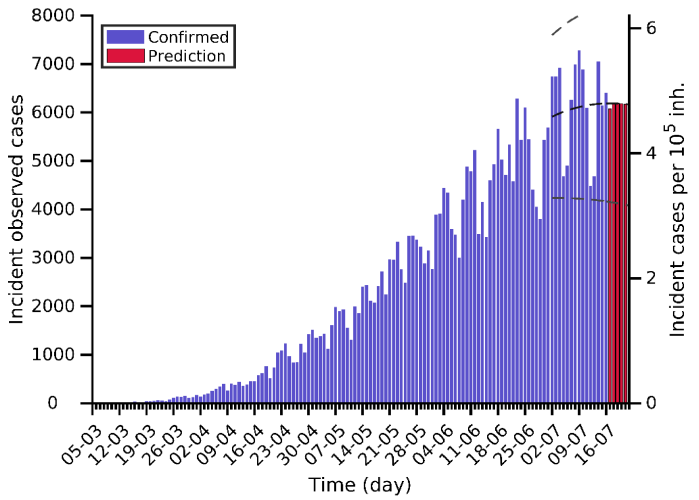


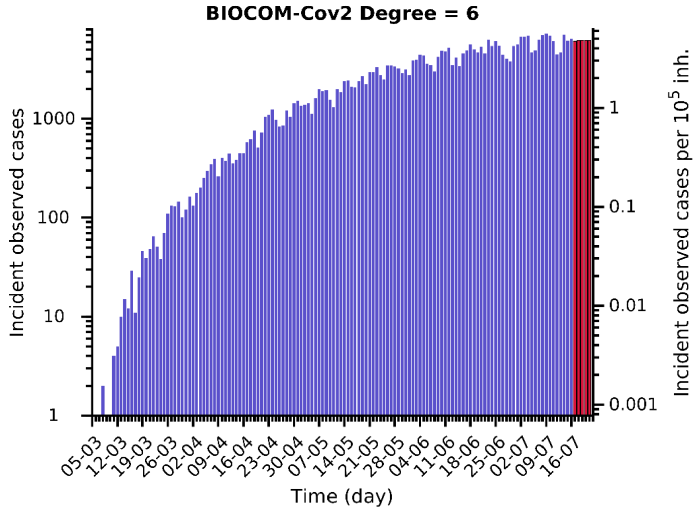


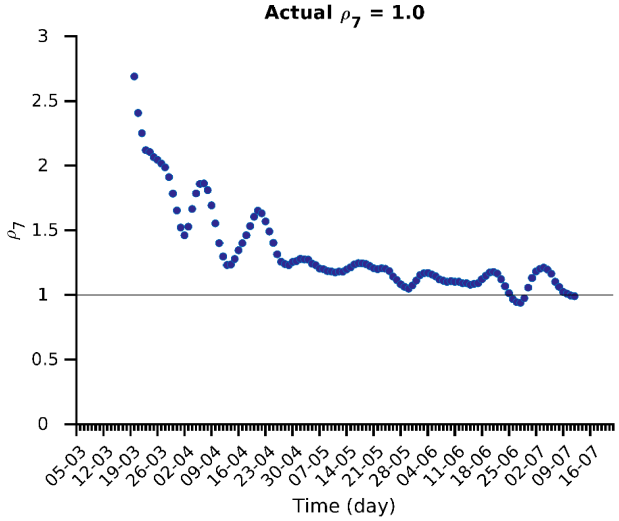
Mexico 16-07-2020. Pop: 128.9M. Cumulative incidence: 251/10⁵

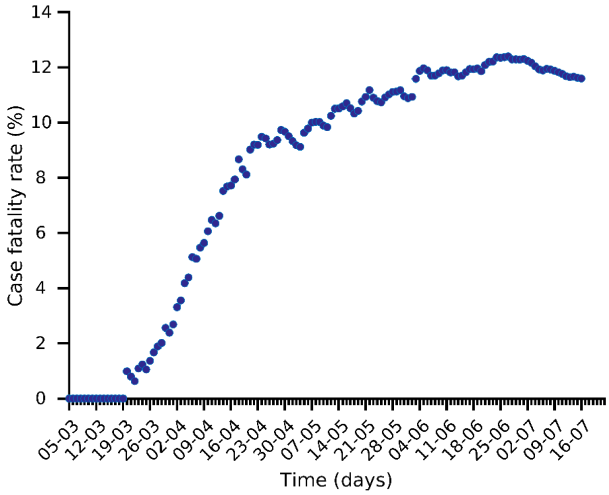


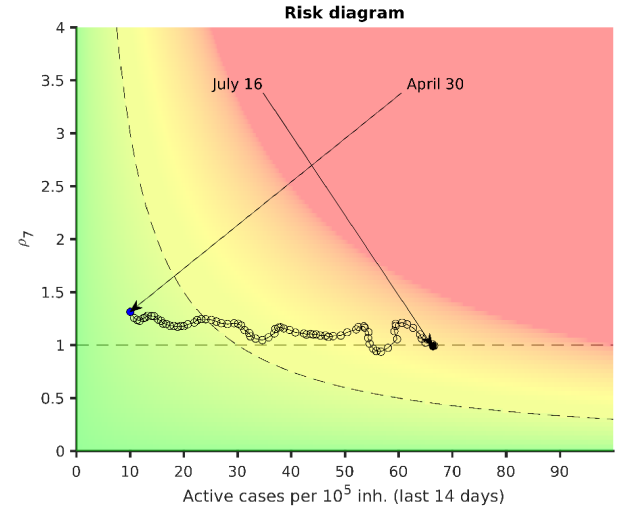


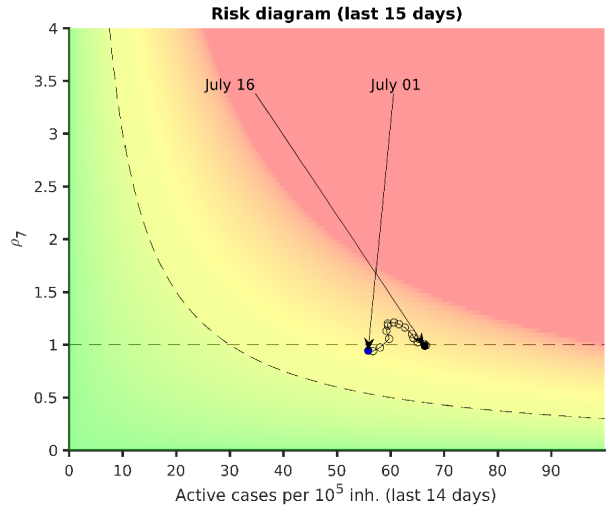




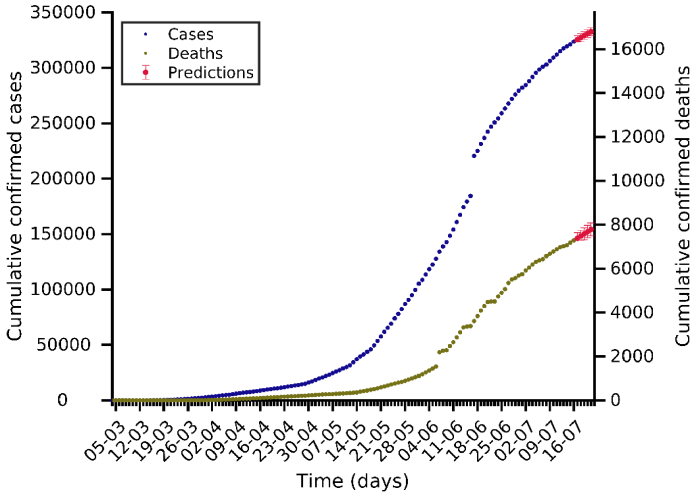


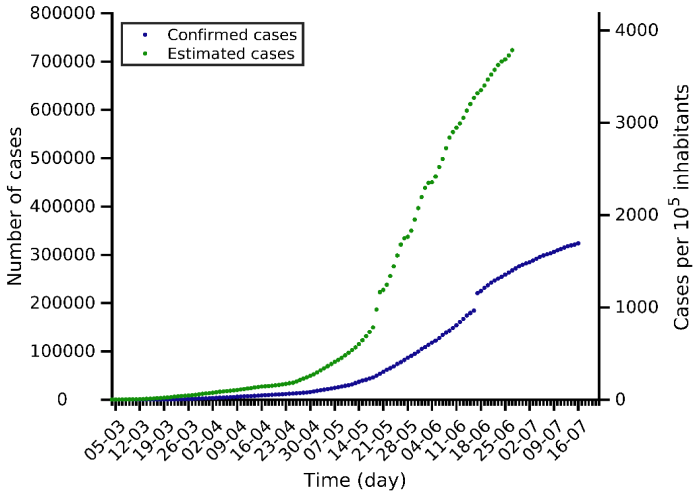


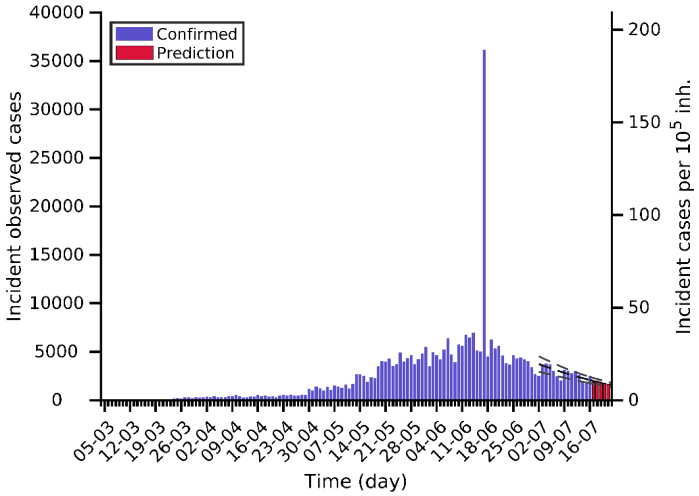


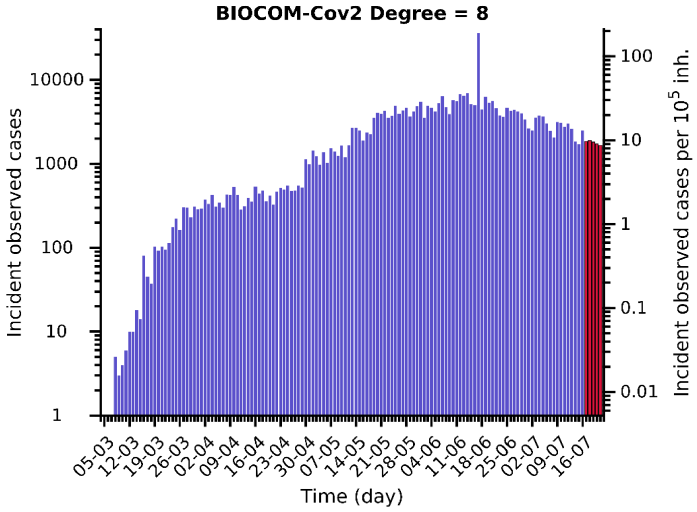


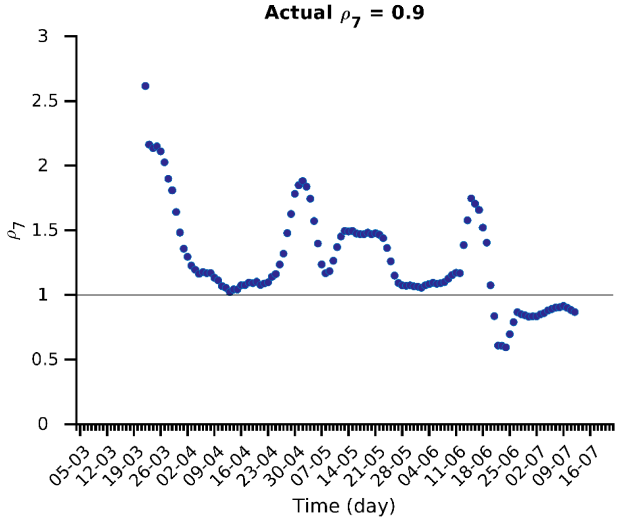
Chile 16-07-2020. Pop: 19.1M. Cumulative incidence: 1693/10^5

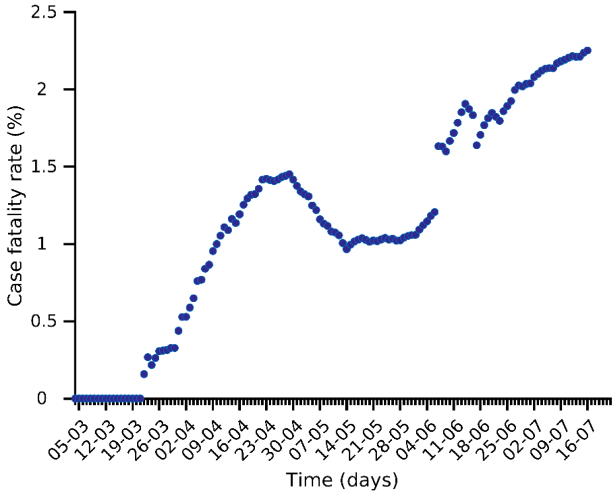


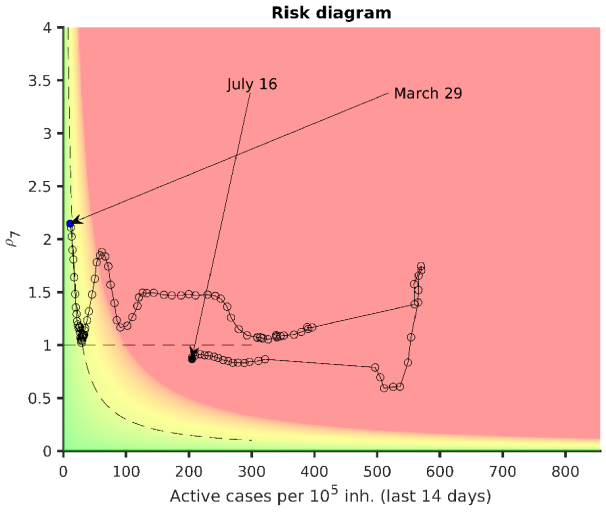


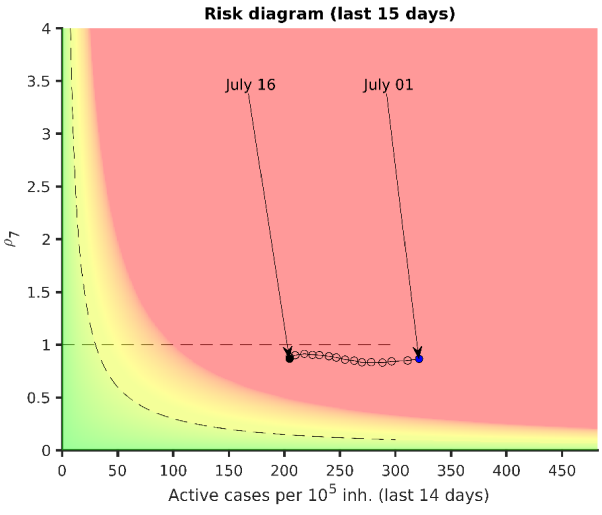




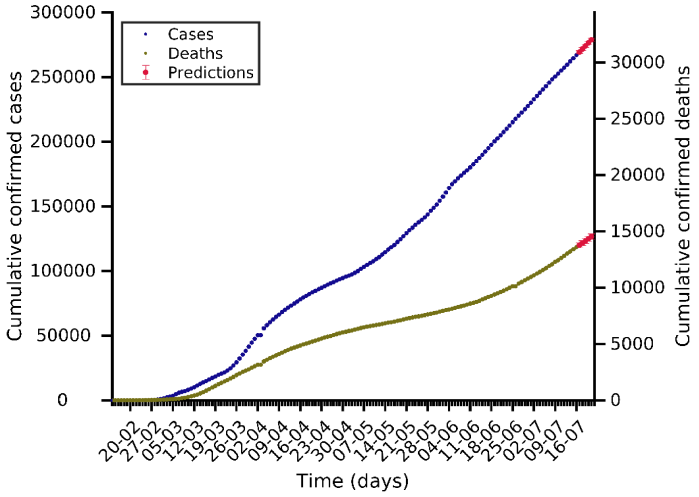


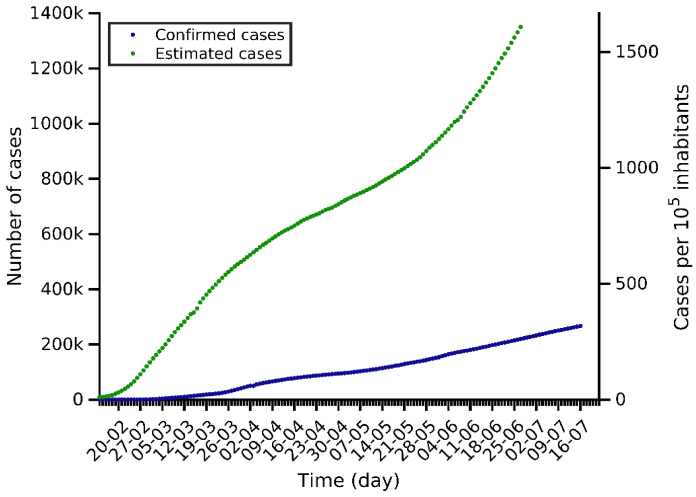


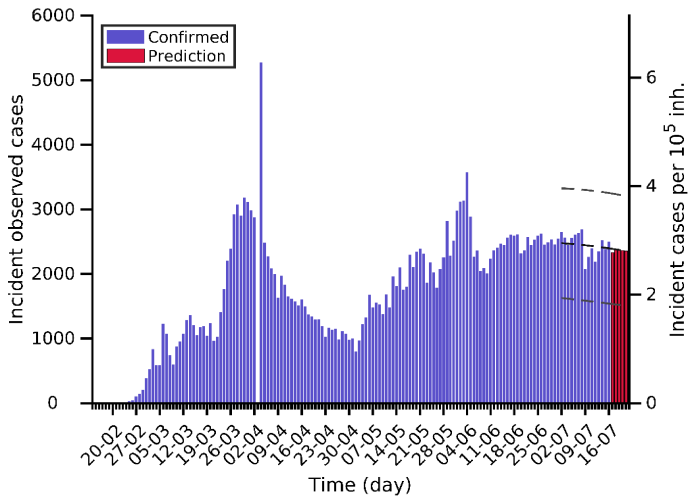


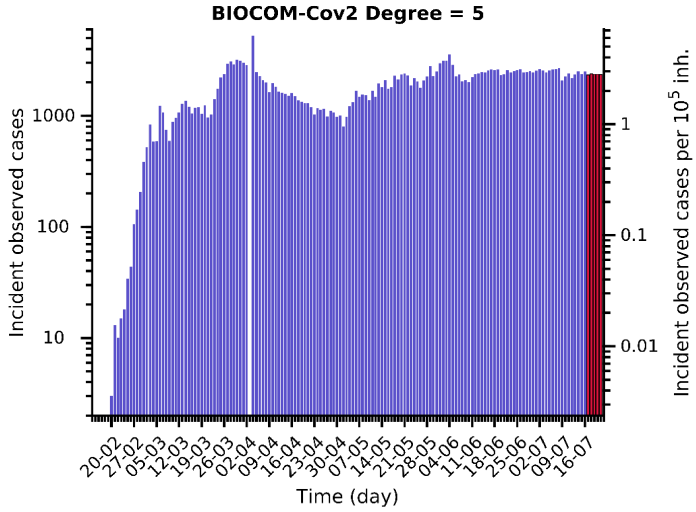


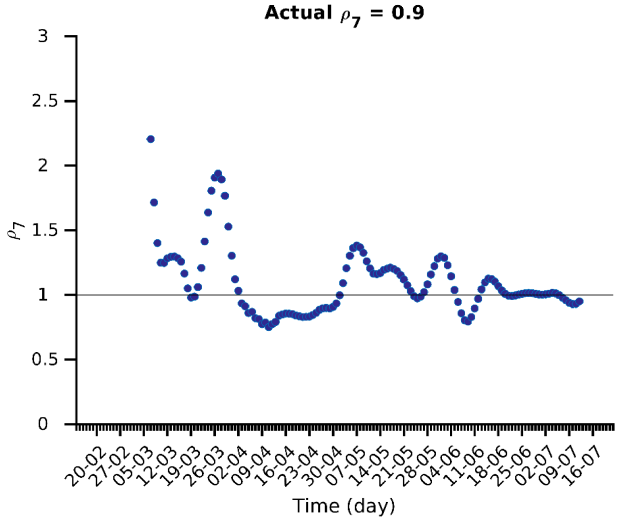
Iran 16-07-2020. Pop: 84.0M. Cumulative incidence: 318/10⁵

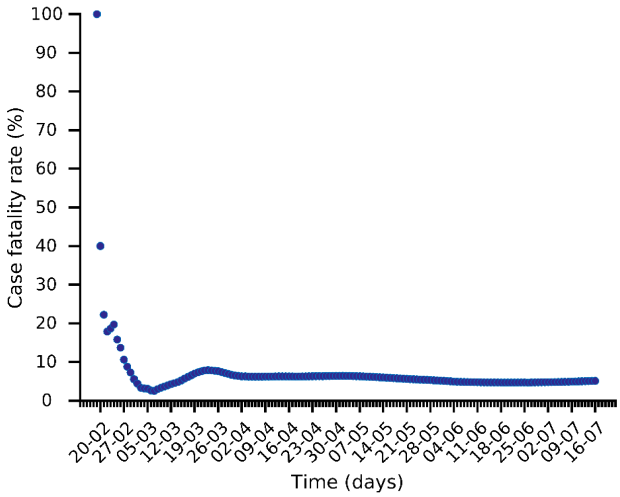


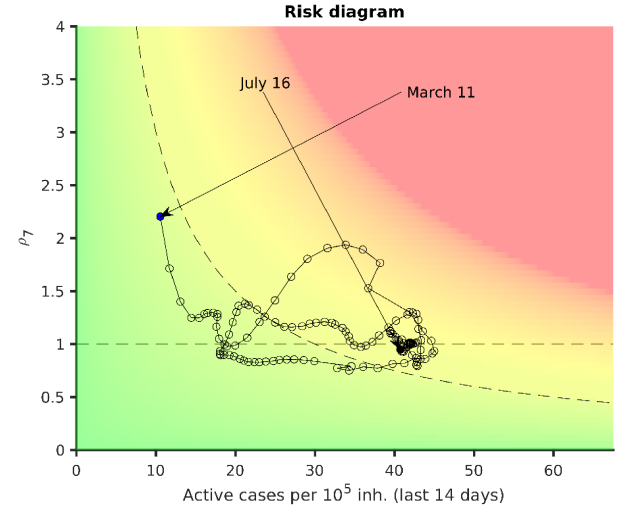


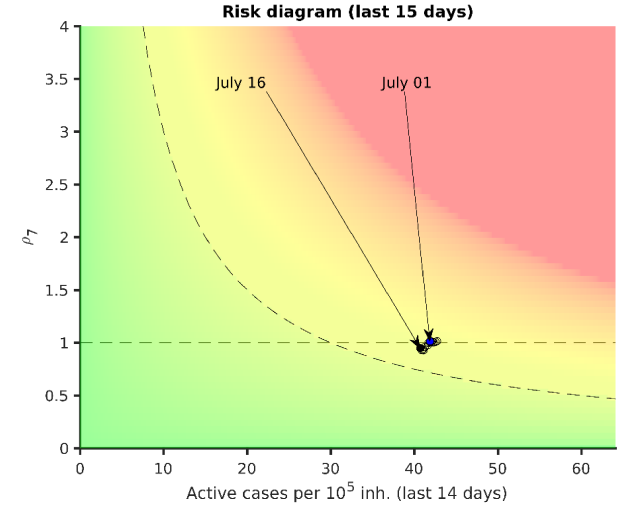




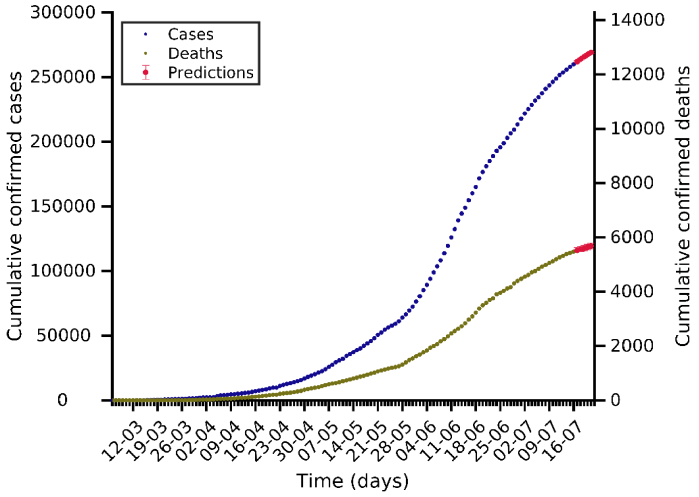


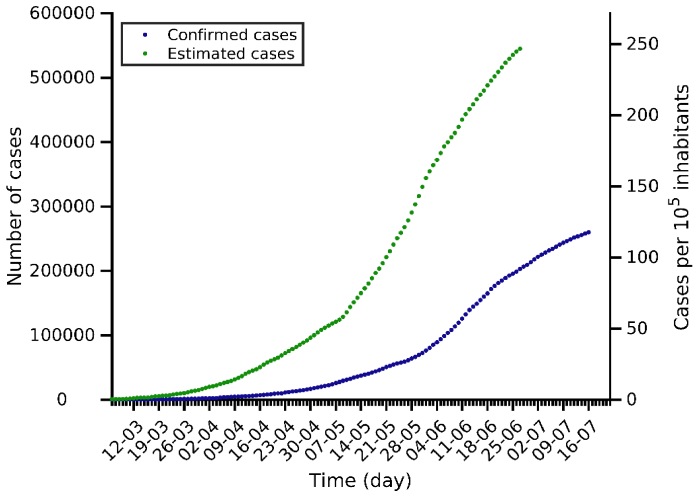


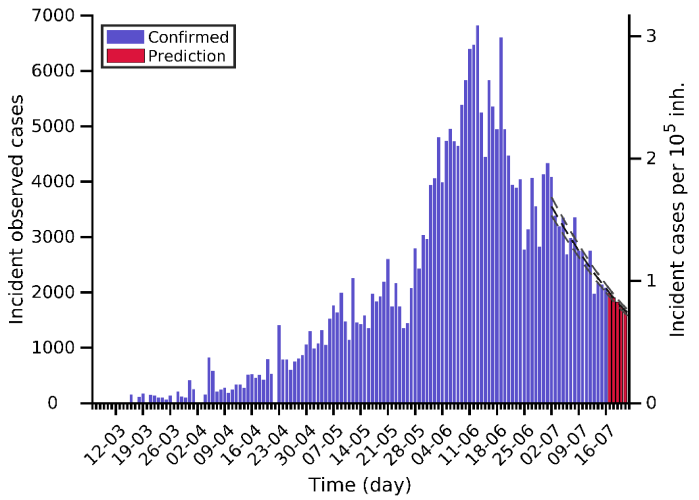


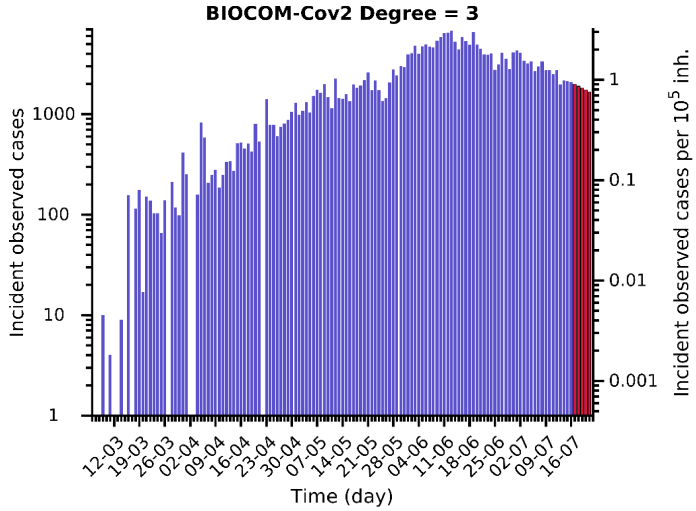


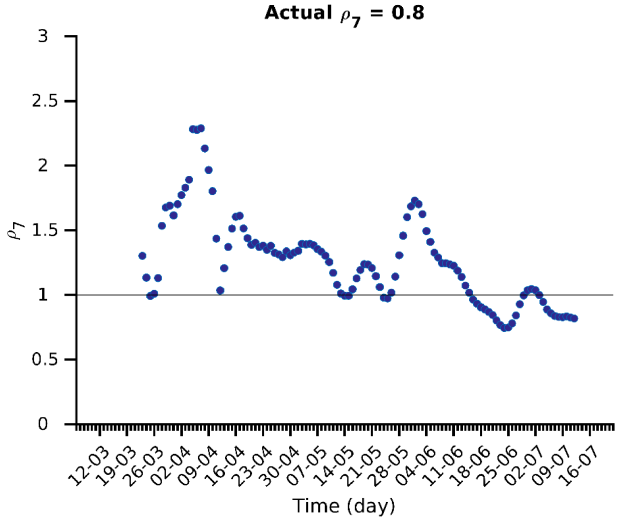
Pakistan 16-07-2020. Pop: 220.9M. Cumulative incidence: 118/10⁵

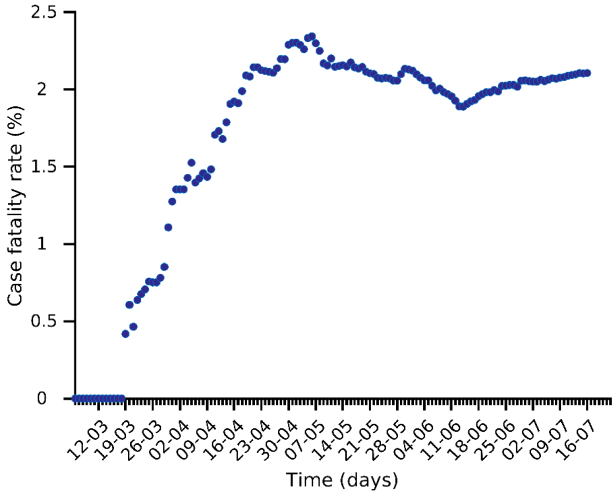


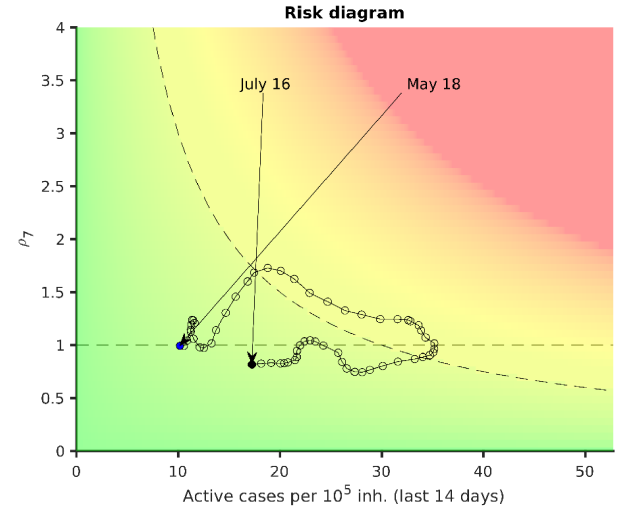


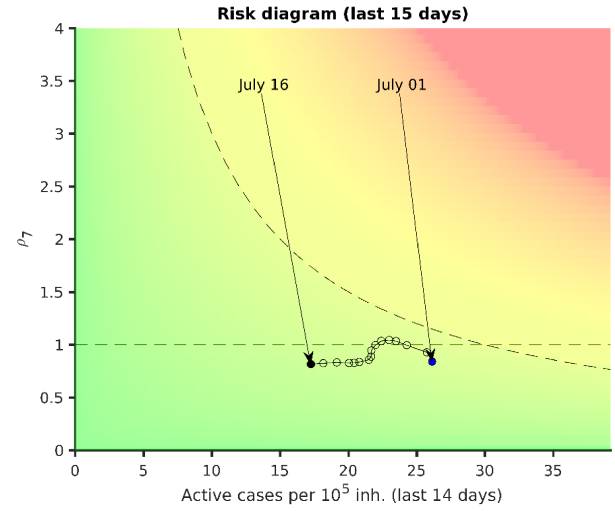




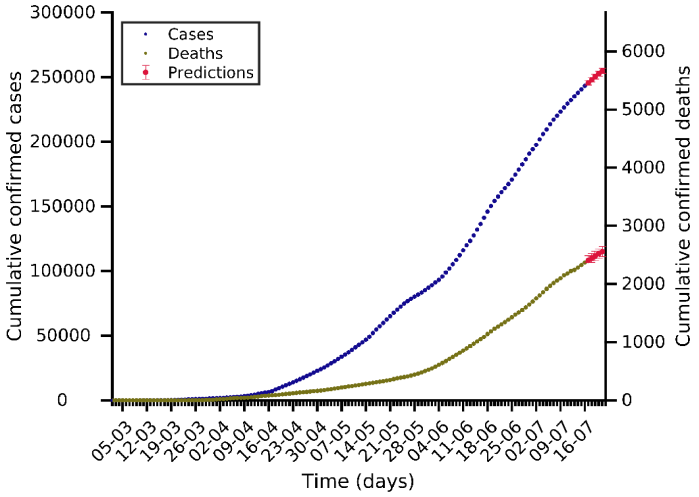


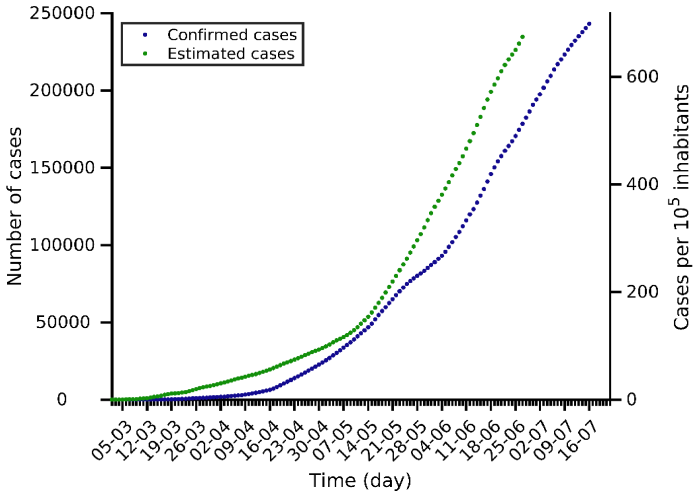


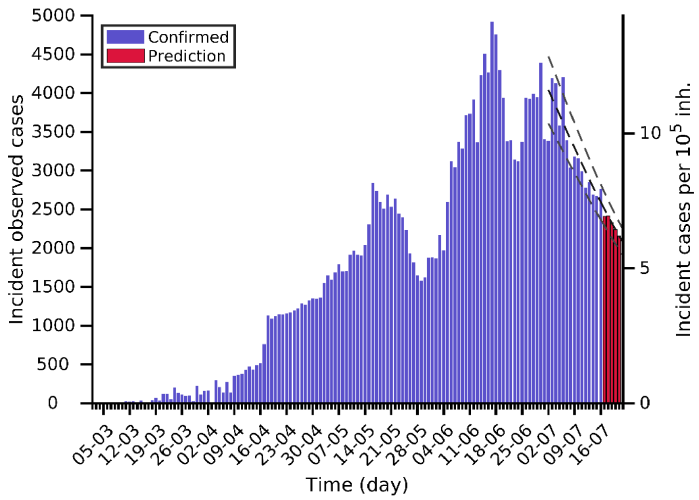


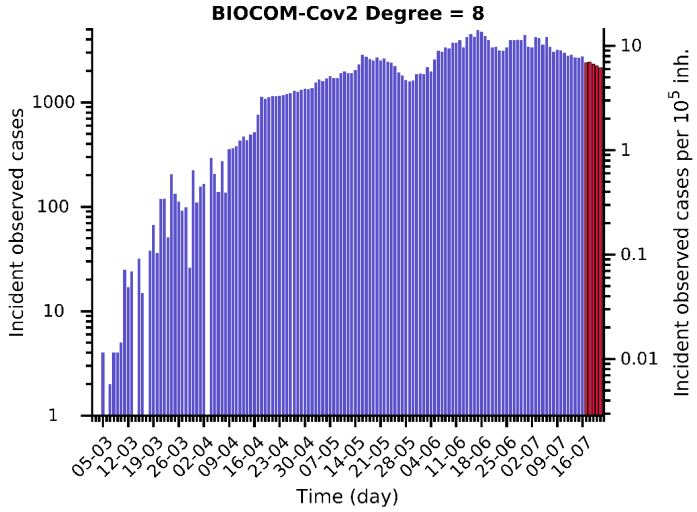


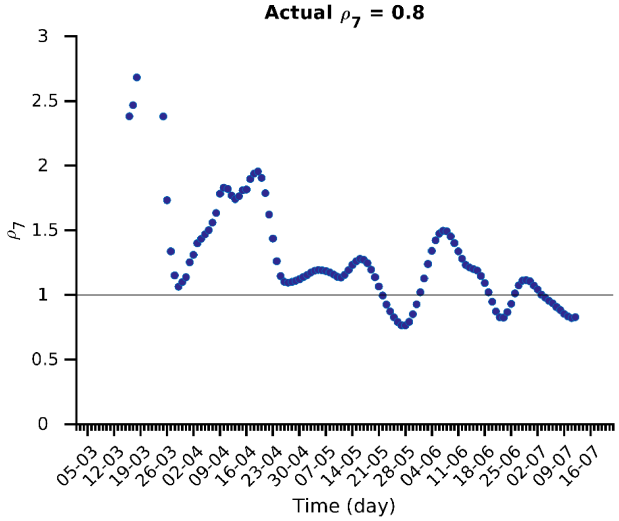
Saudi Arabia 16-07-2020. Pop: 34.8M. Cumulative incidence: 699/10⁵

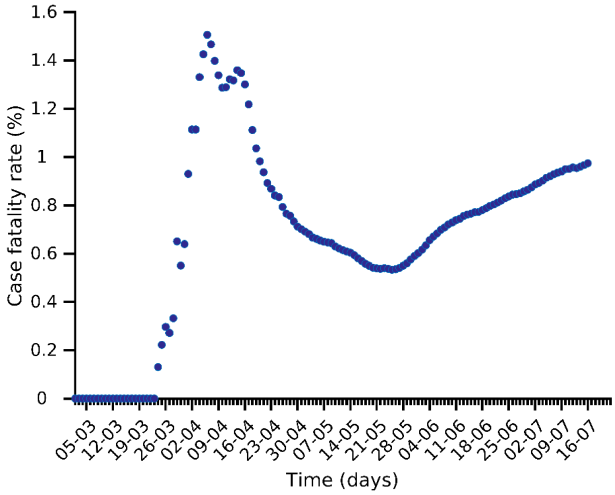


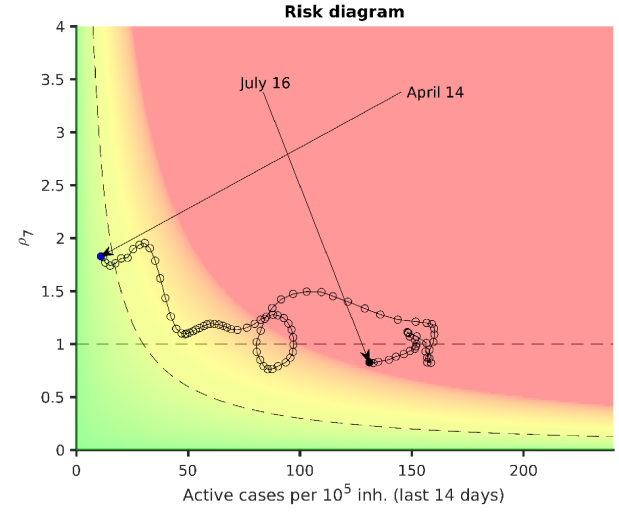


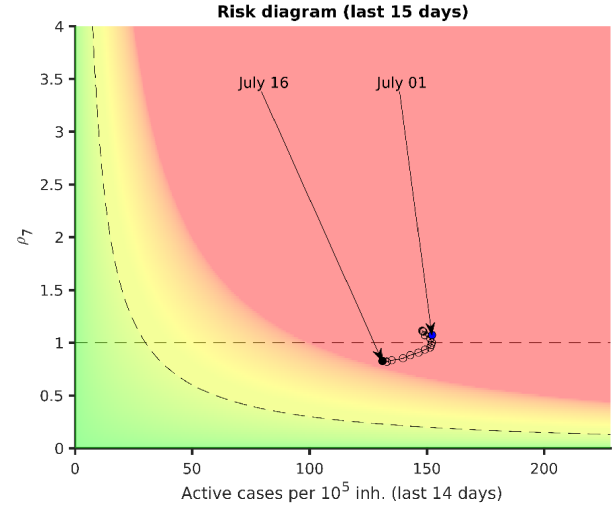




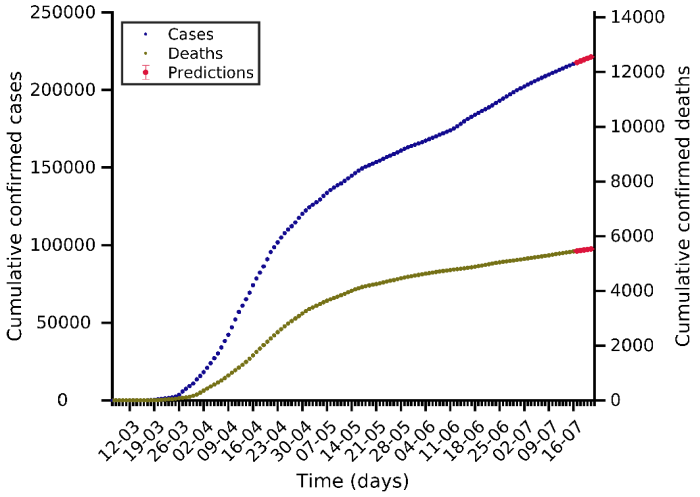


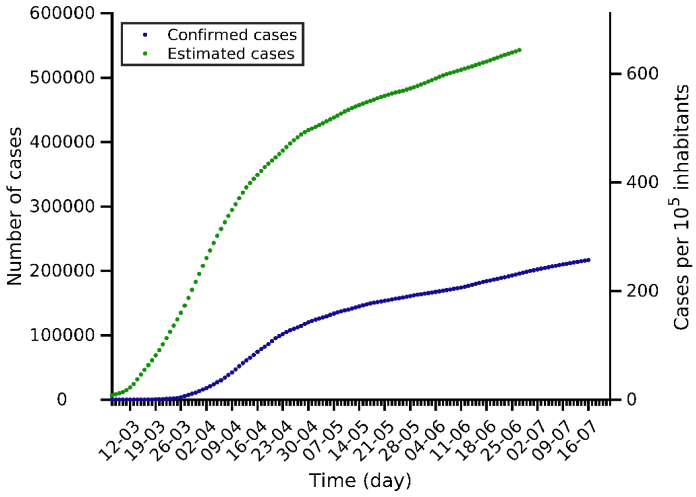


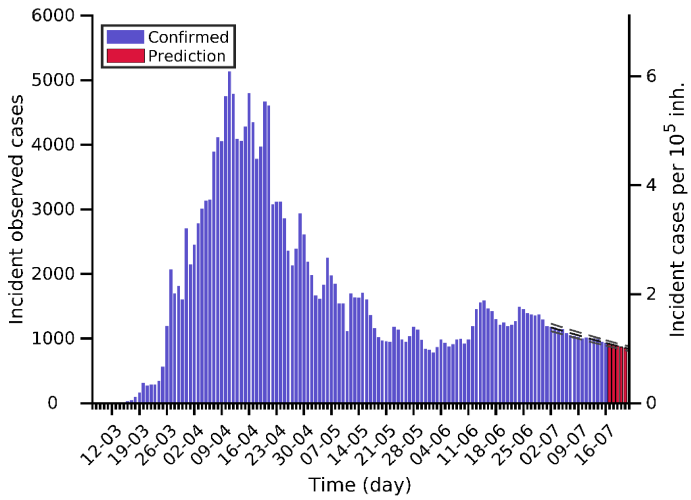


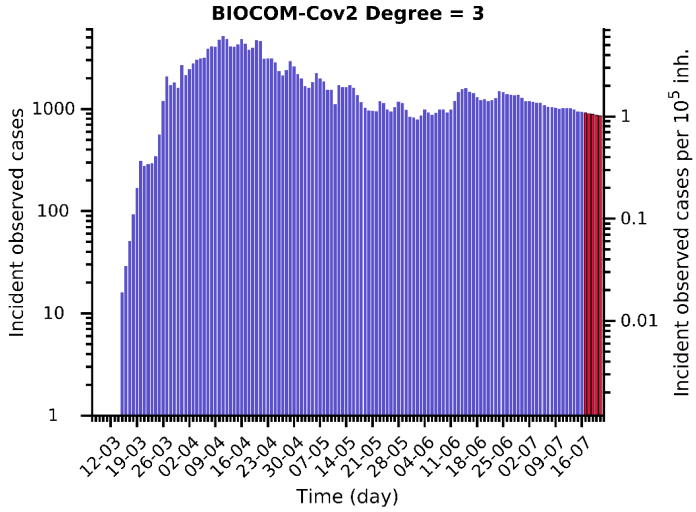


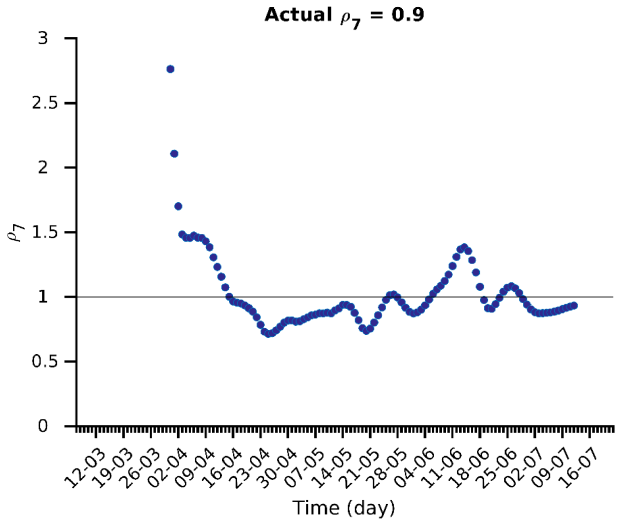
Turkey 16-07-2020. Pop: 84.3M. Cumulative incidence: 257/10⁵

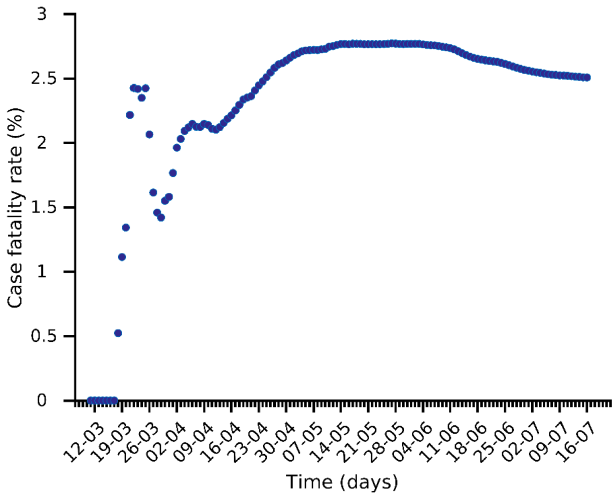


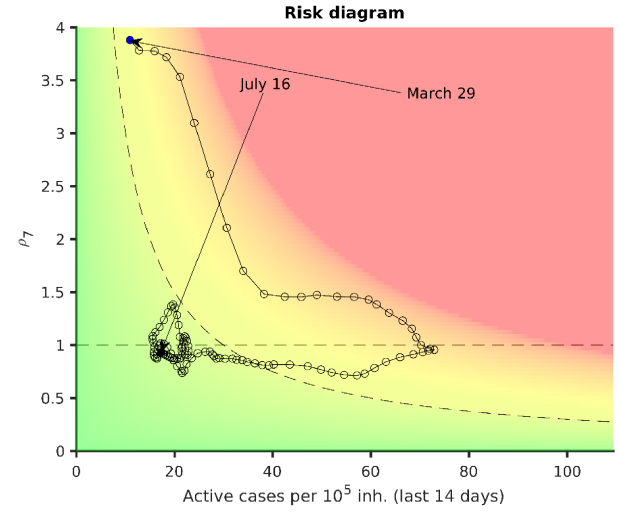


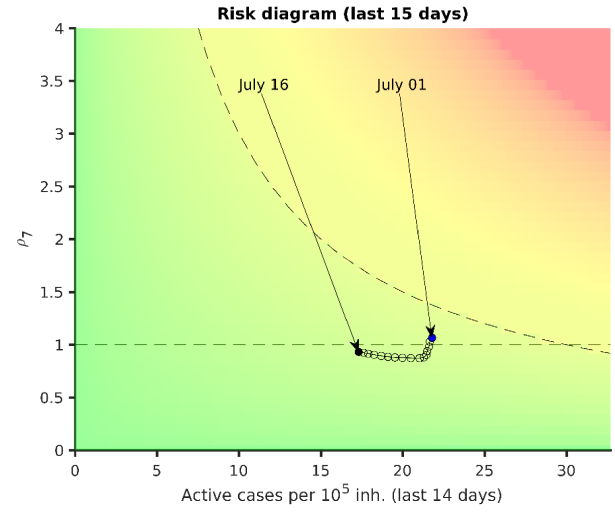




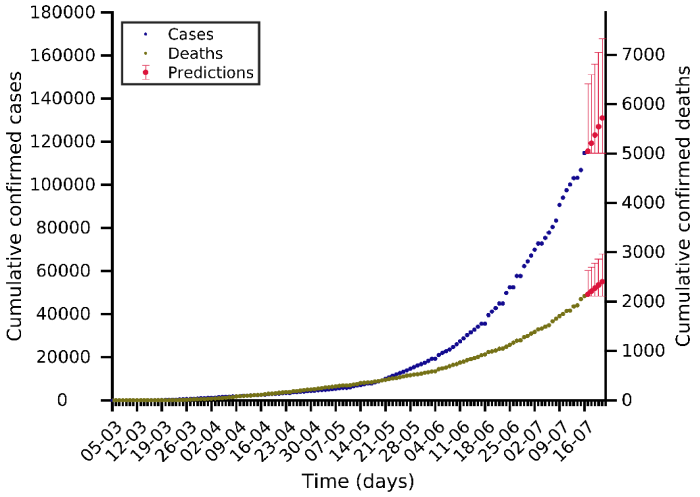


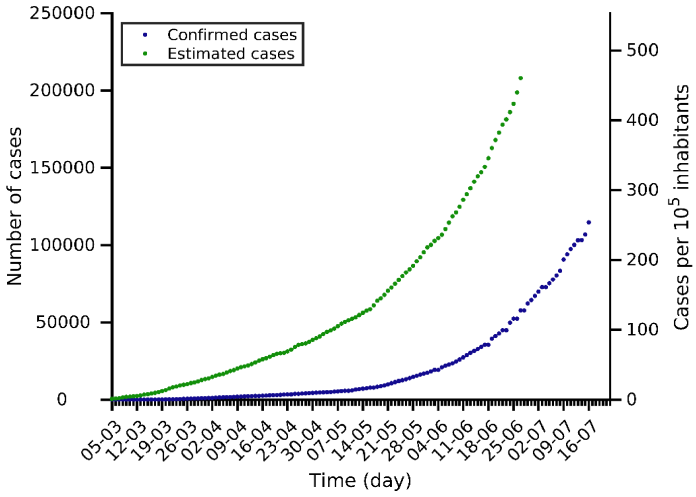


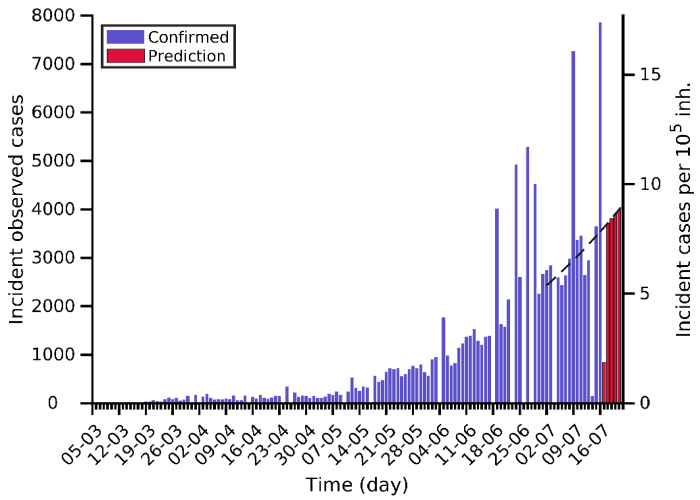


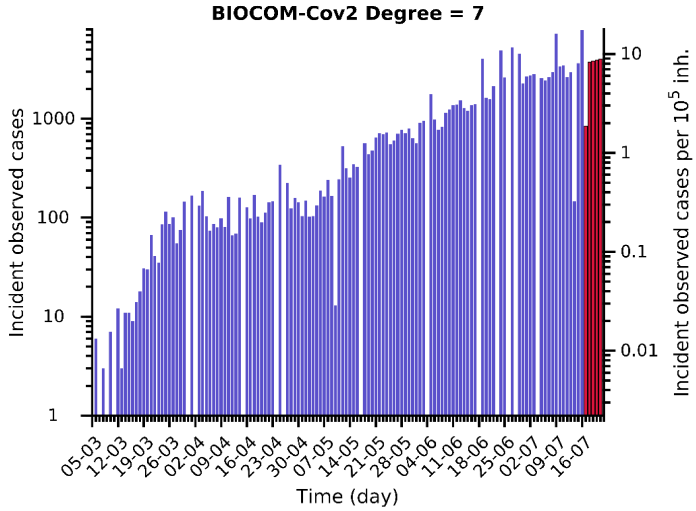


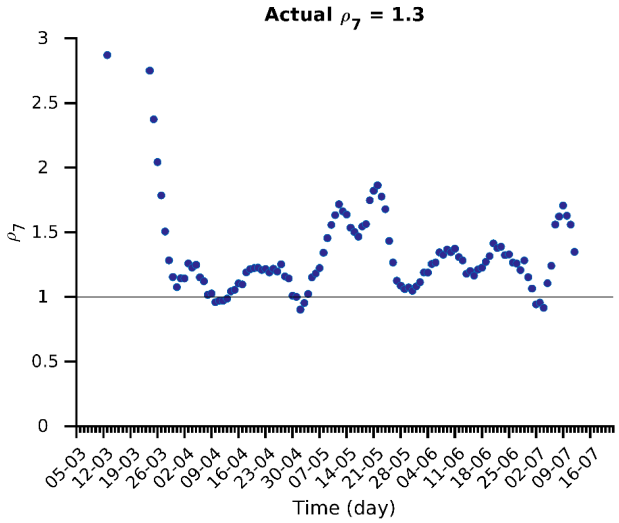
Argentina 16-07-2020. Pop: 45.2M. Cumulative incidence: 254/10⁵

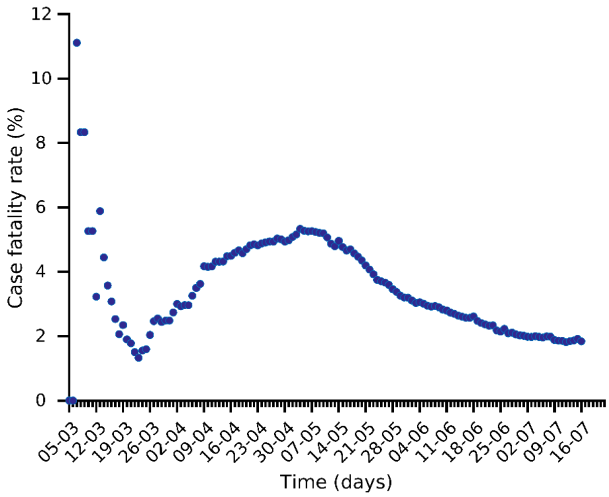


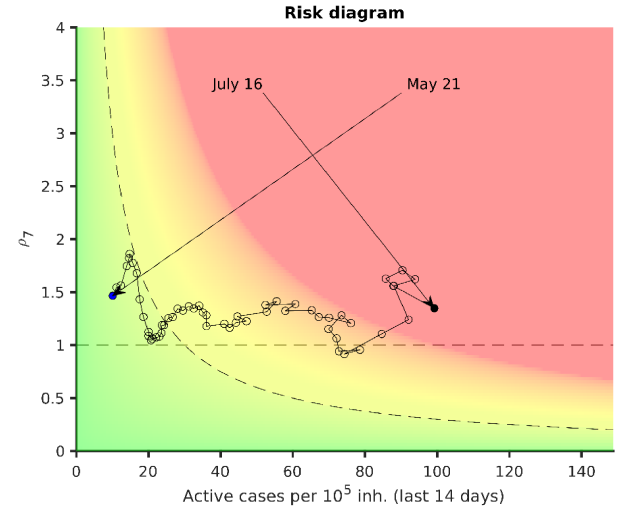


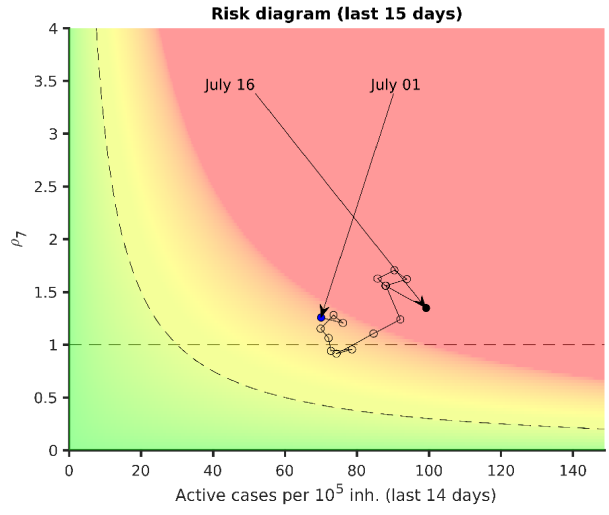




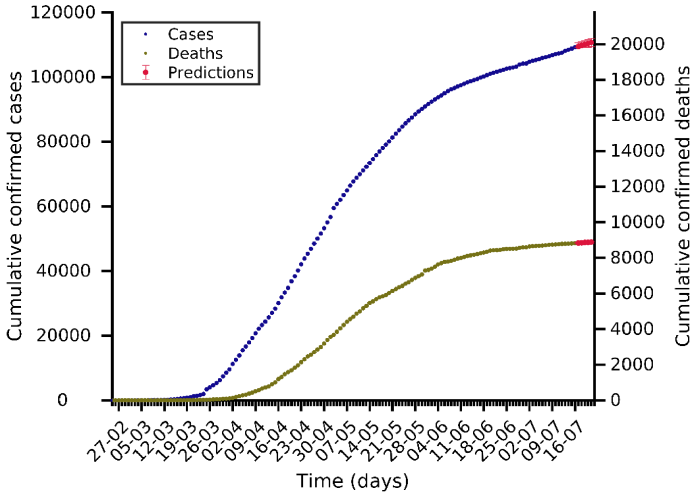


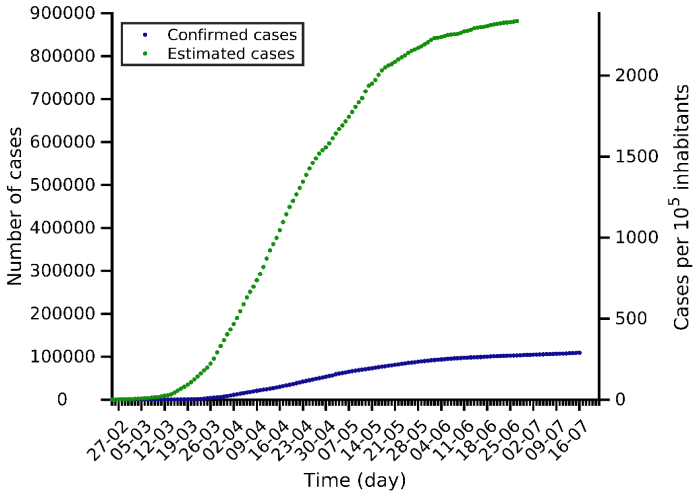


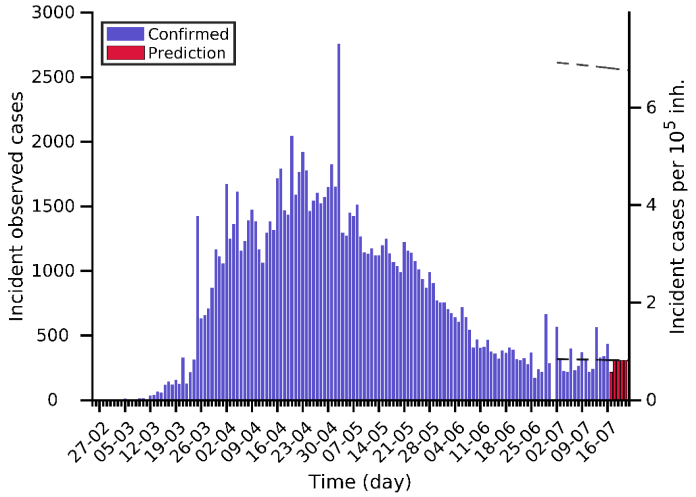


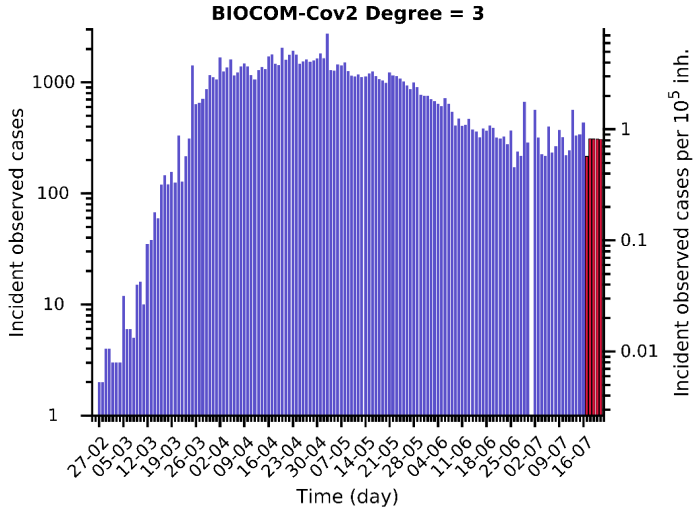


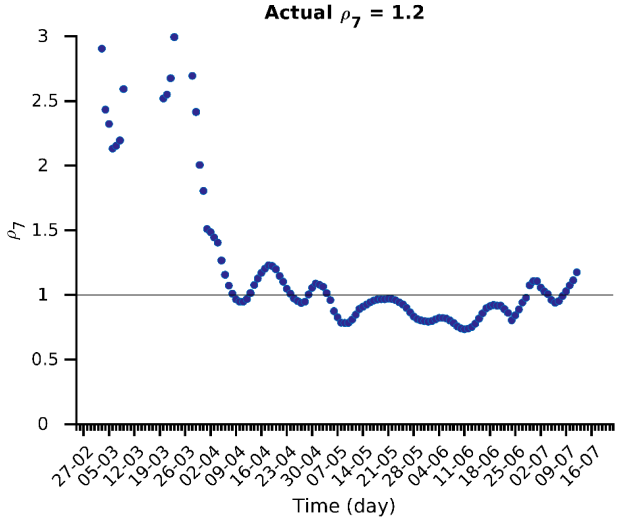
Canada 16-07-2020. Pop: 37.7M. Cumulative incidence: 289/10^5

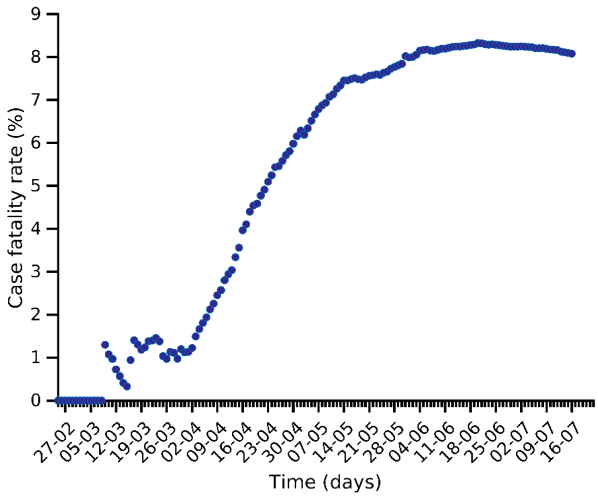


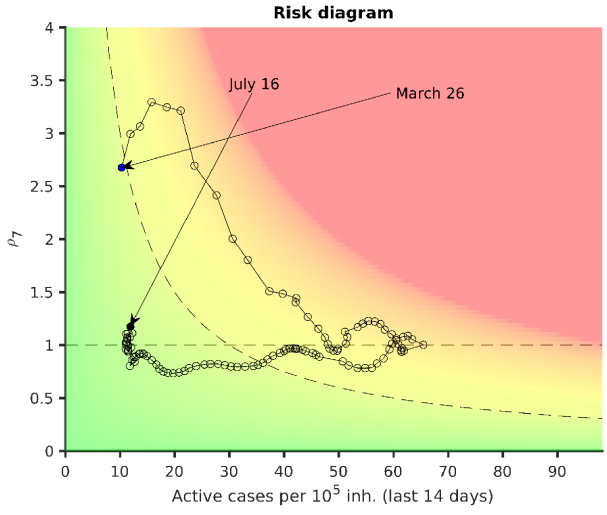


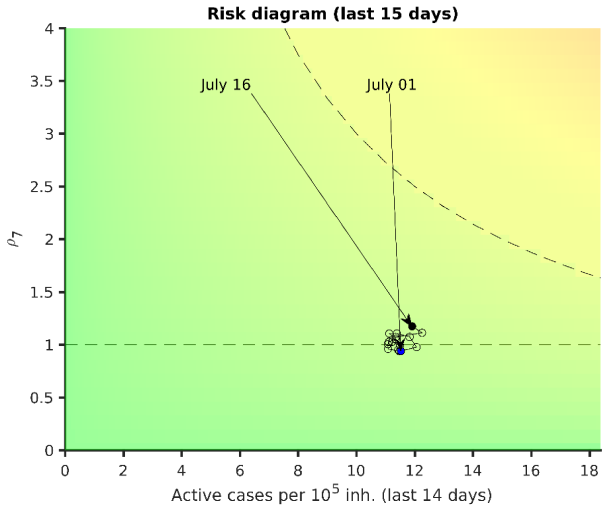




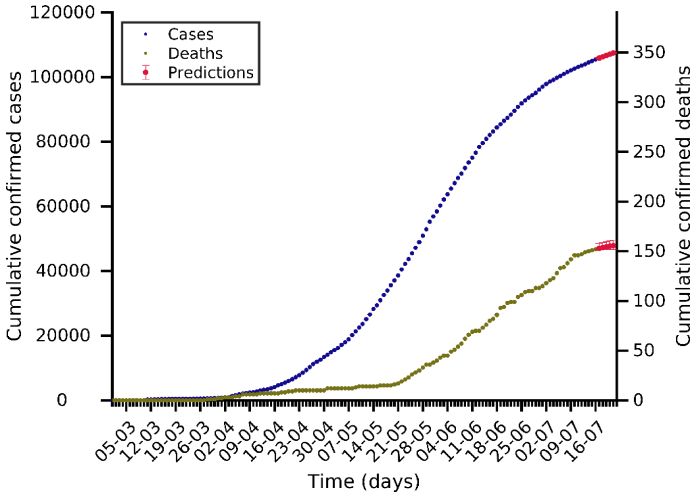


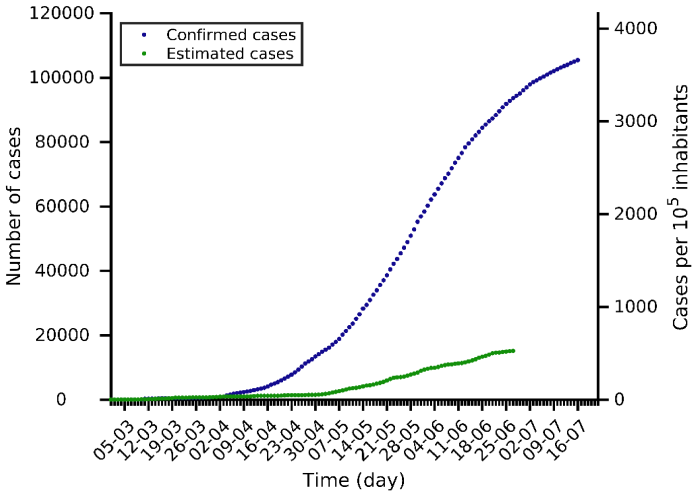


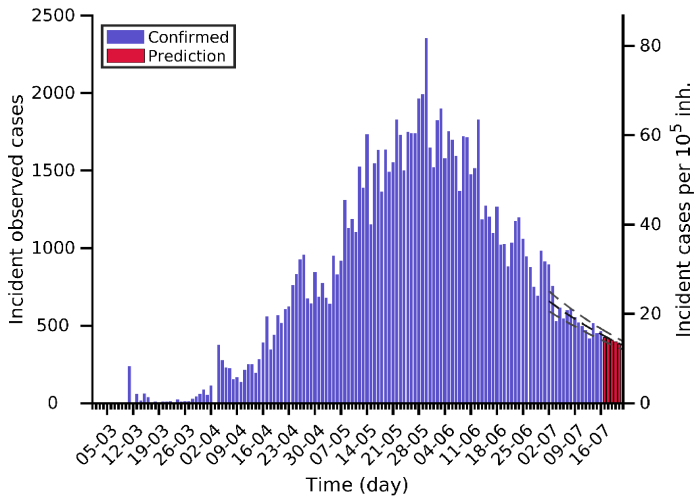


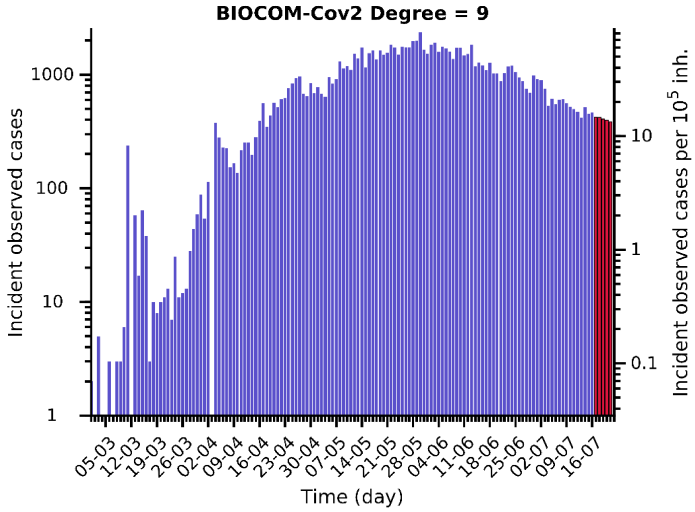


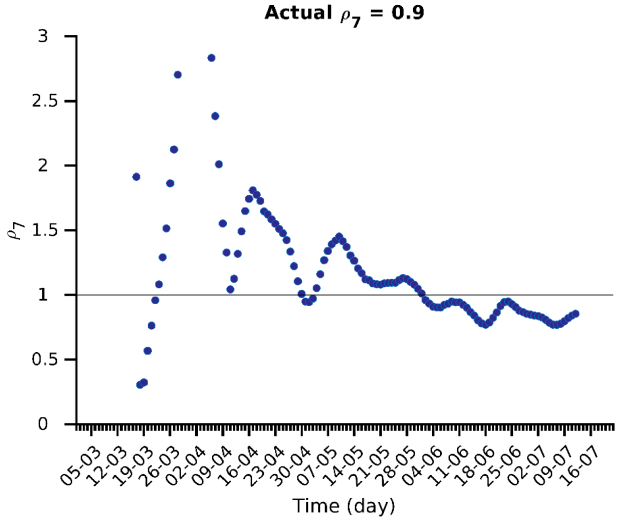
Qatar 16-07-2020. Pop: 2.9M. Cumulative incidence: 3660/10⁵

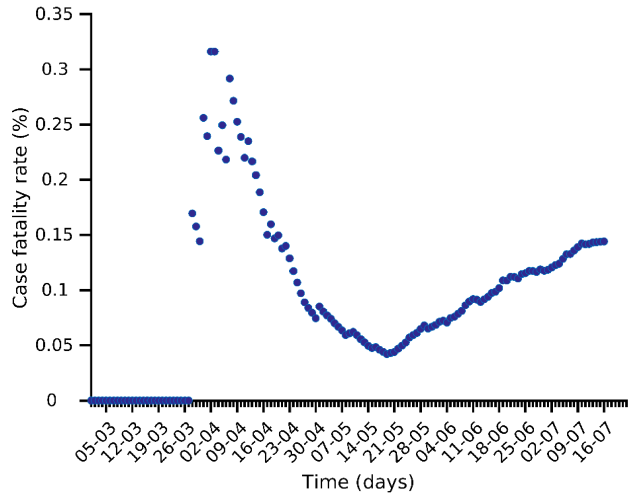


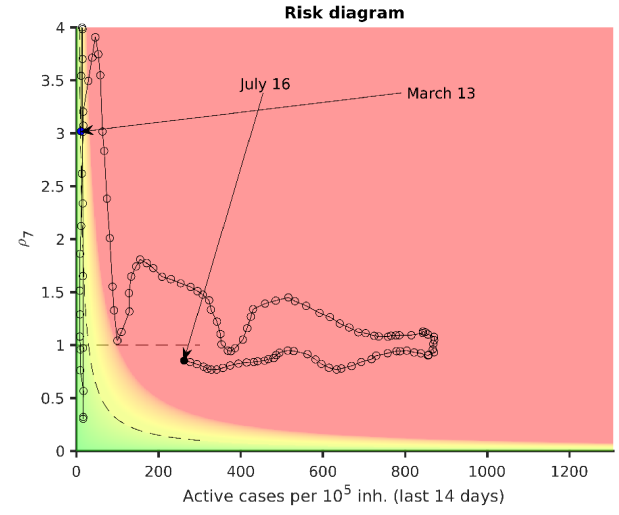


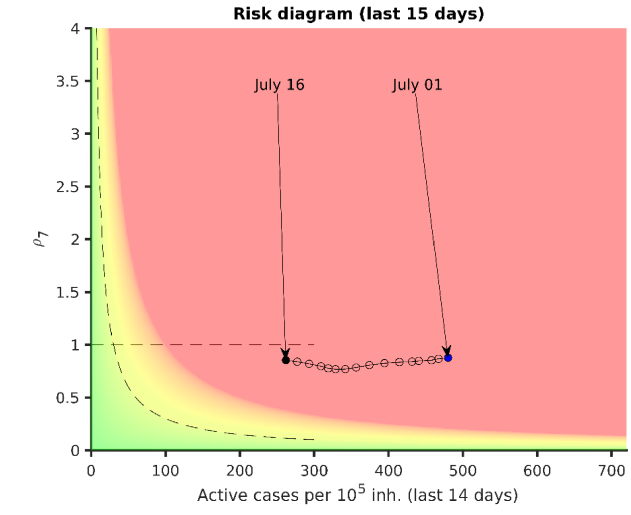




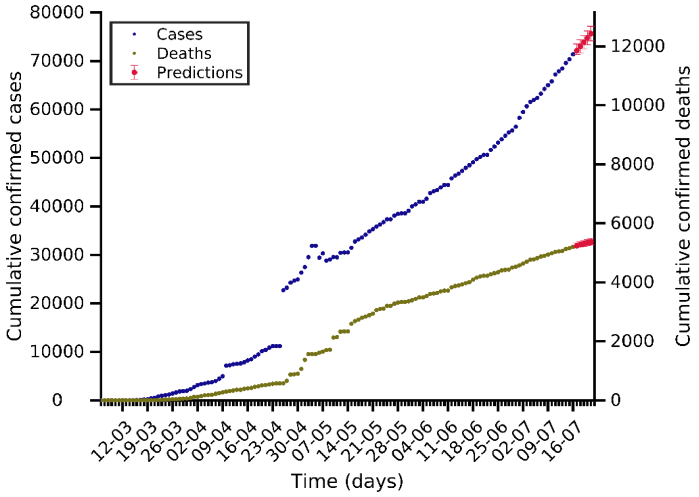


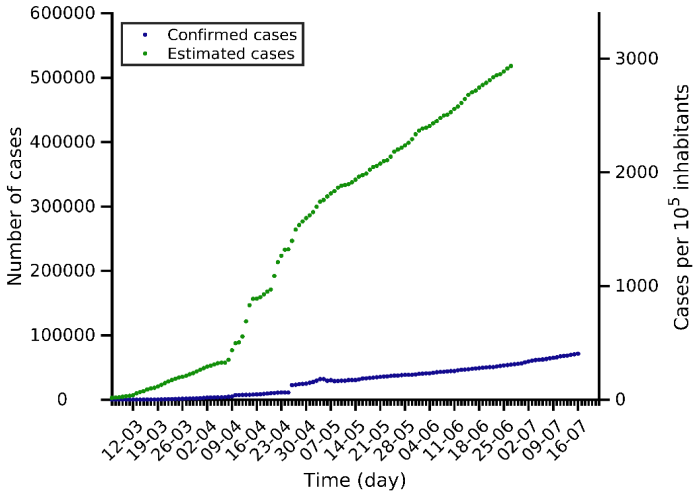


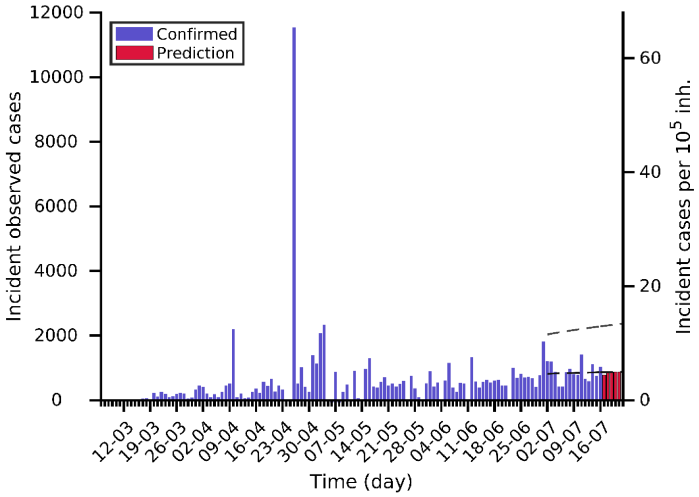


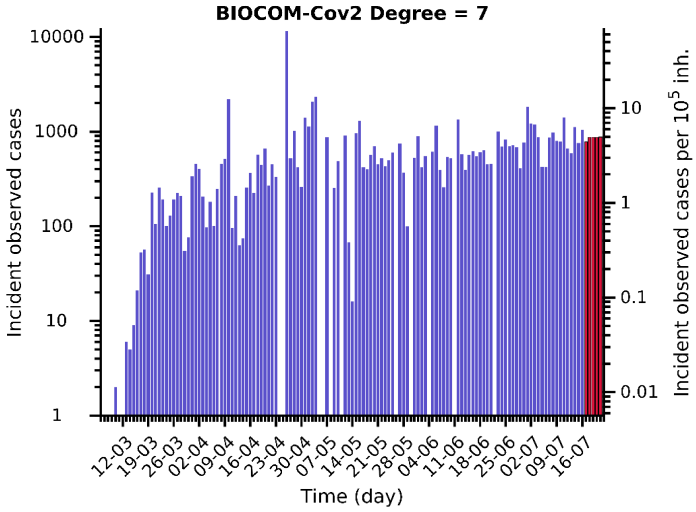


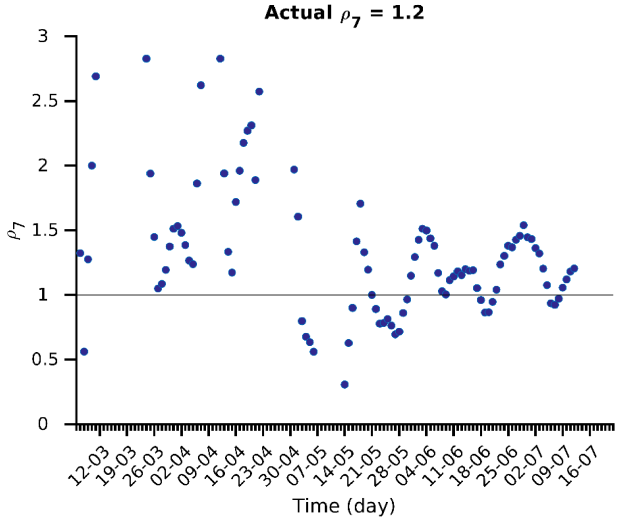
Ecuador 16-07-2020. Pop: 17.6M. Cumulative incidence: 404/10⁵

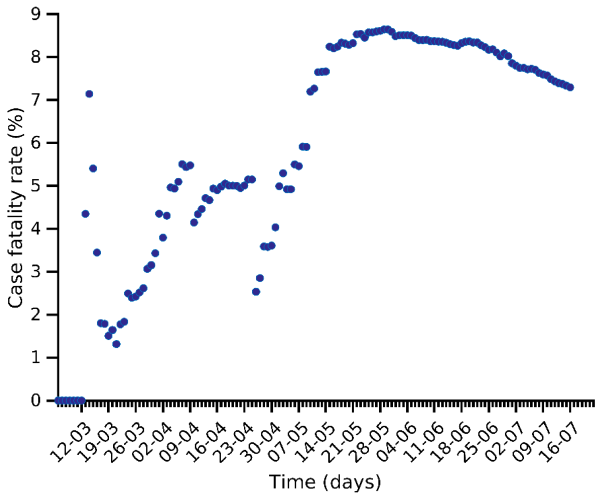


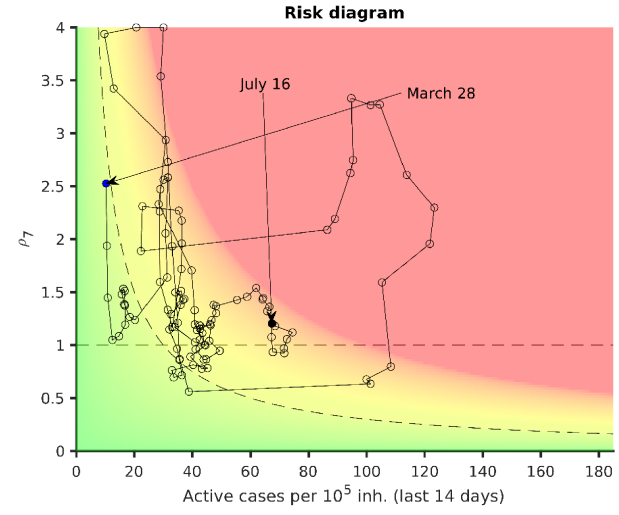


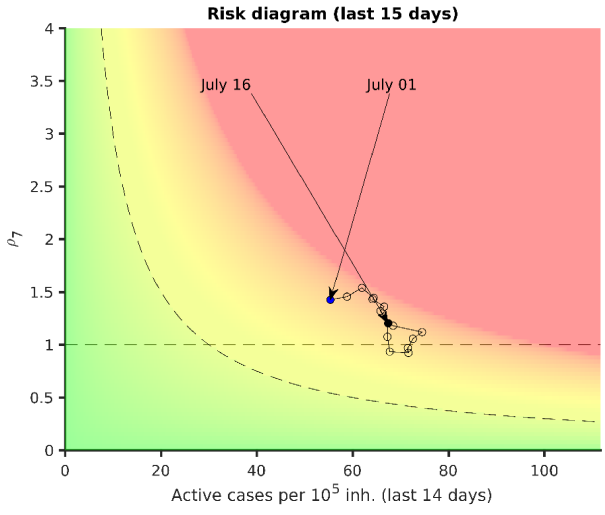




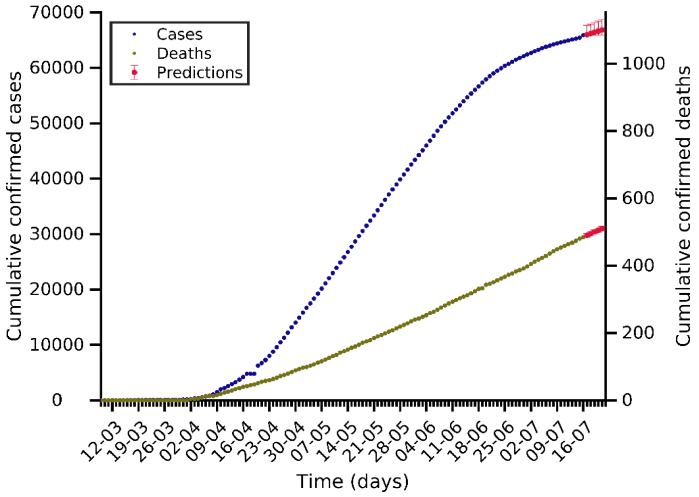


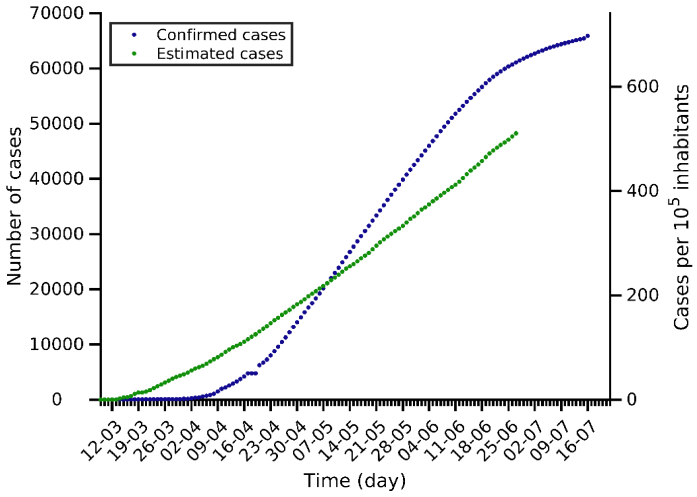


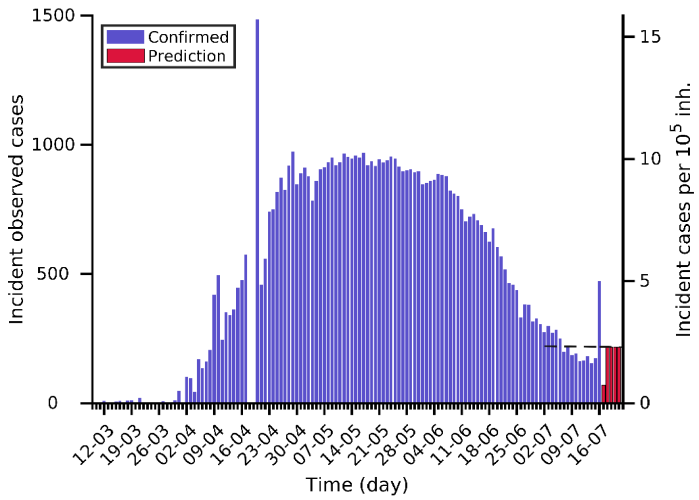


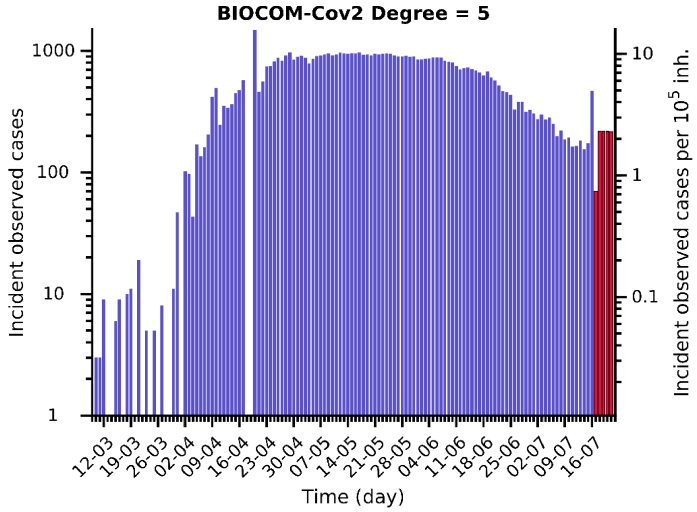


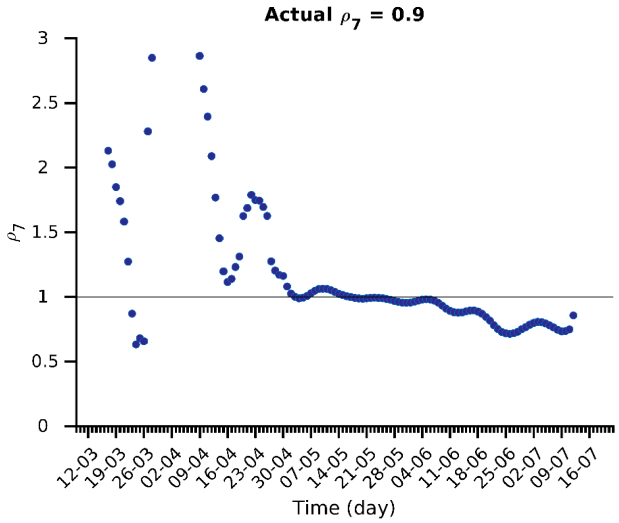
Belarus 16-07-2020. Pop: 9.4M. Cumulative incidence: 698/10^5

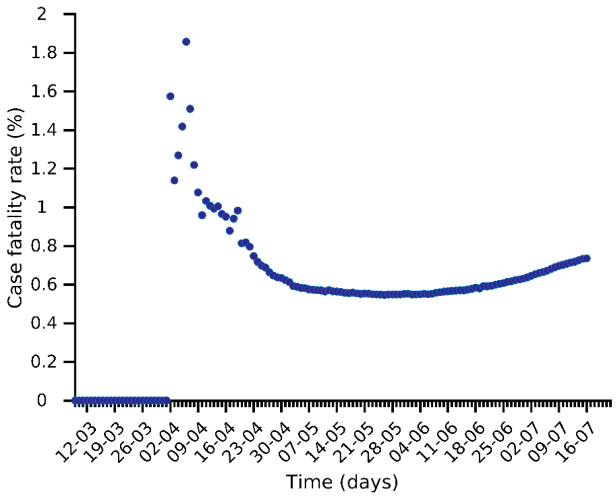


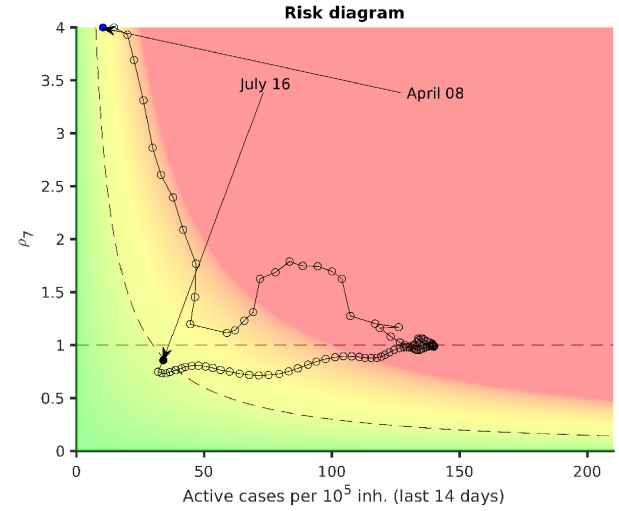


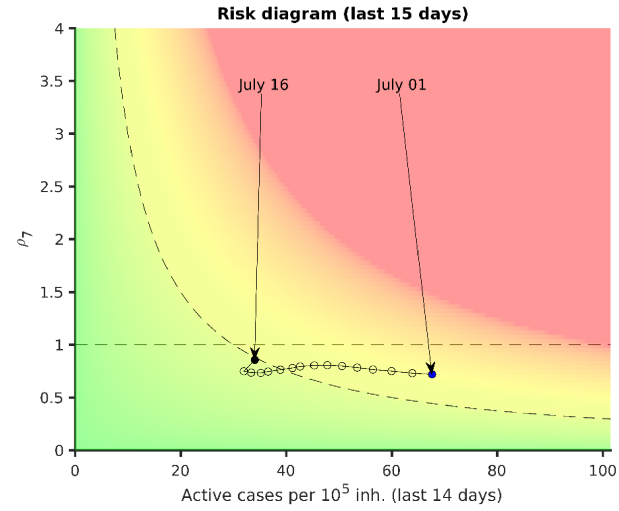




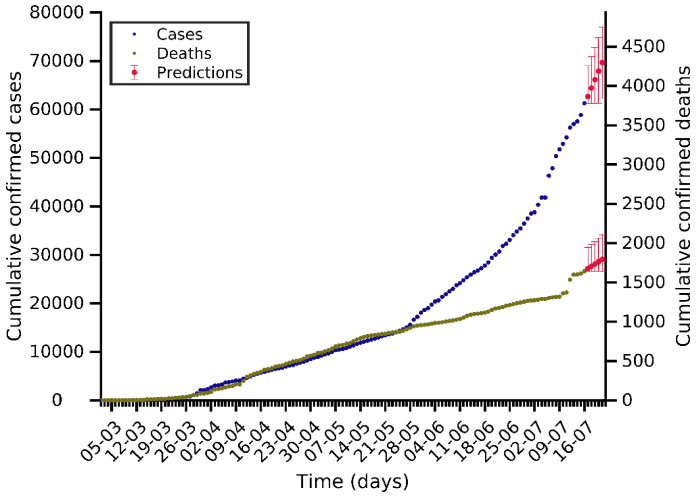


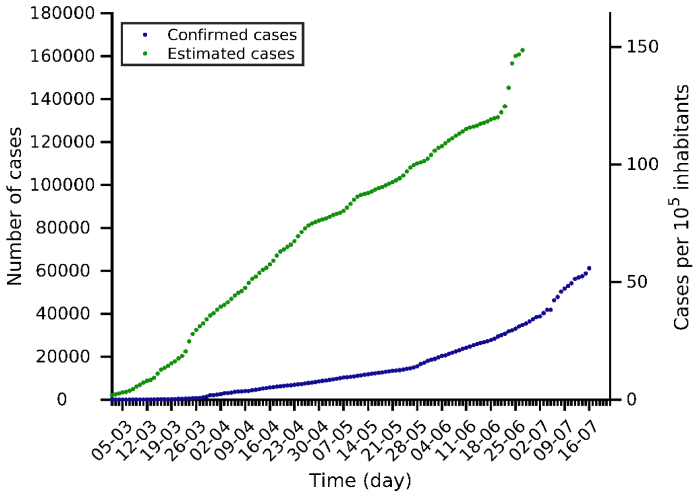


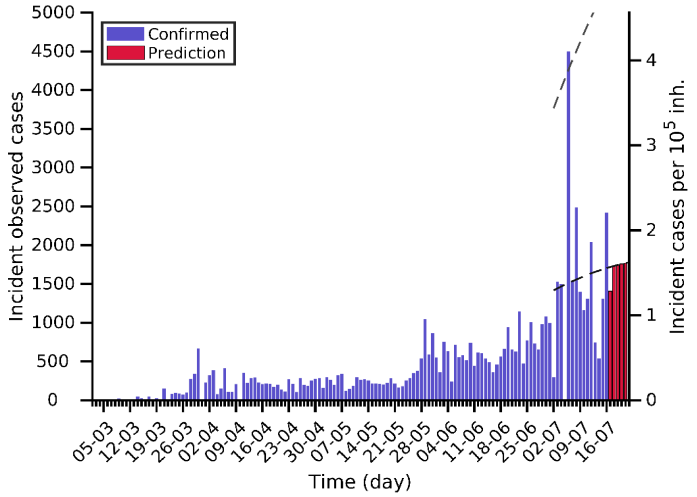


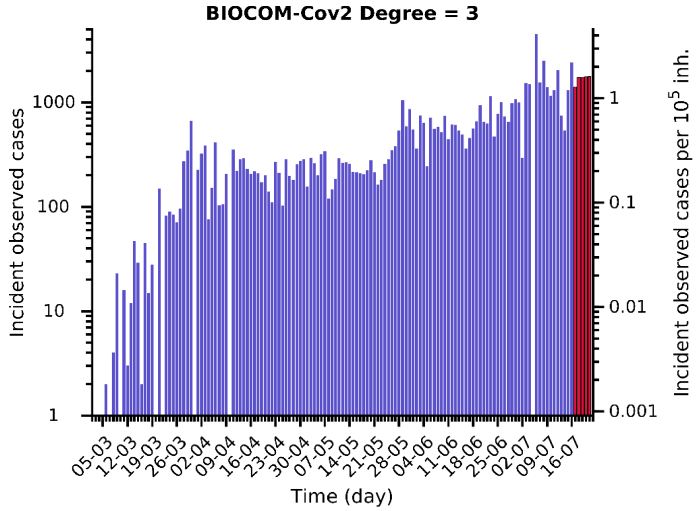


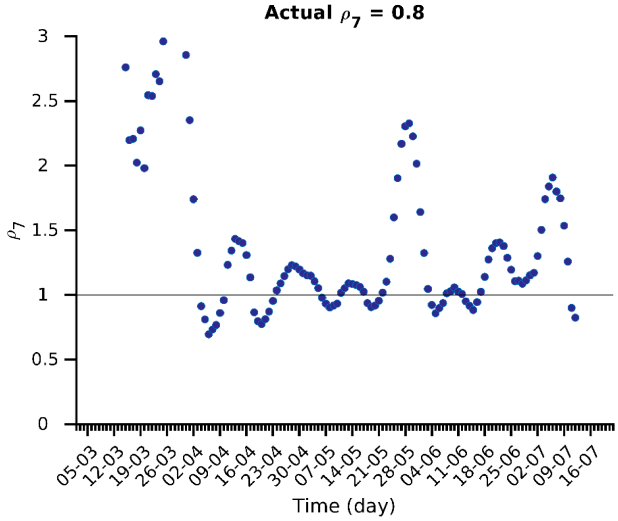
Philippines 16-07-2020. Pop: 109.6M. Cumulative incidence: 56/10^5

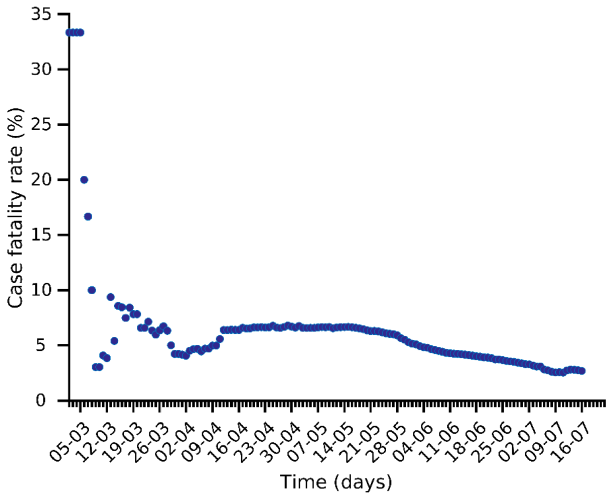


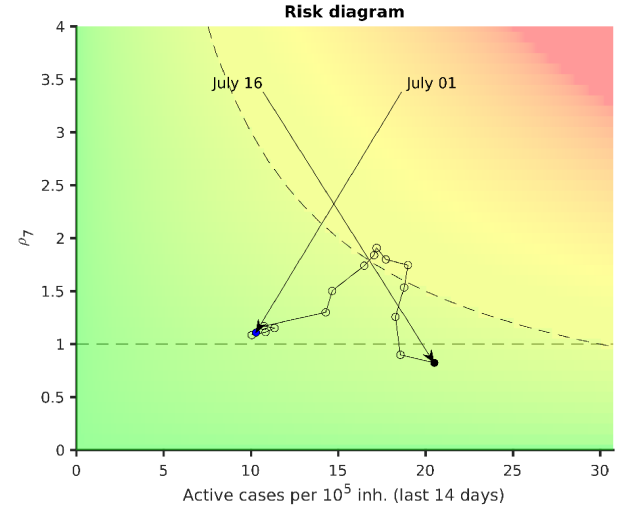


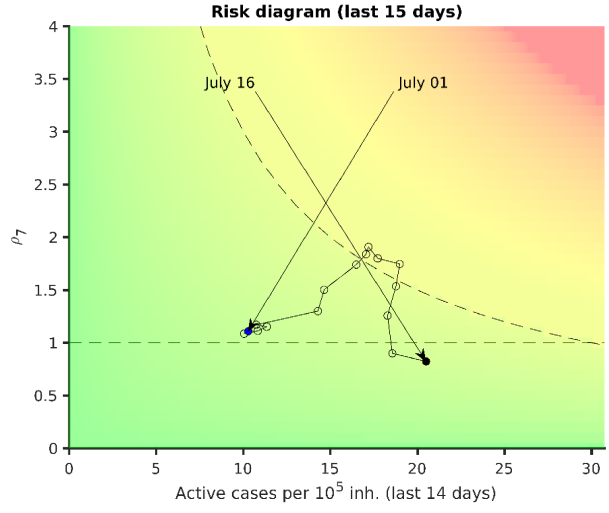




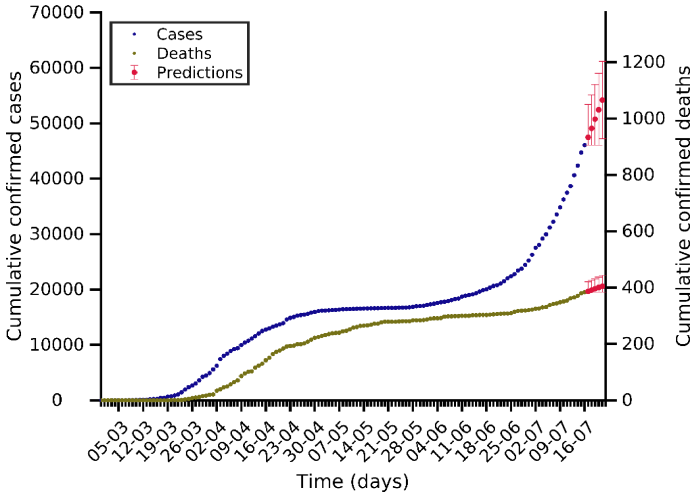


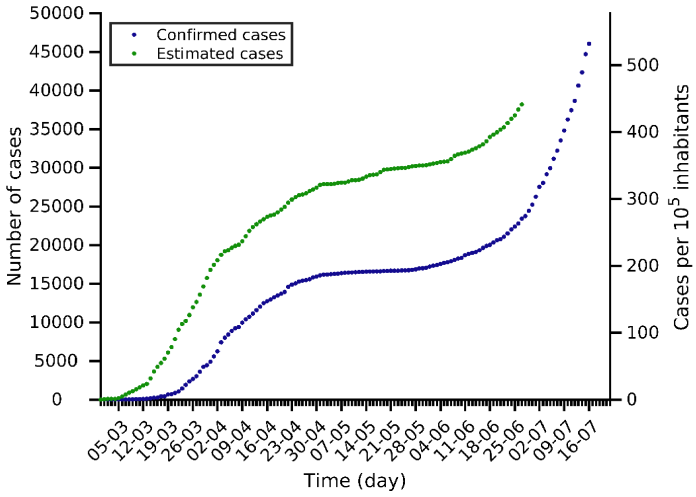


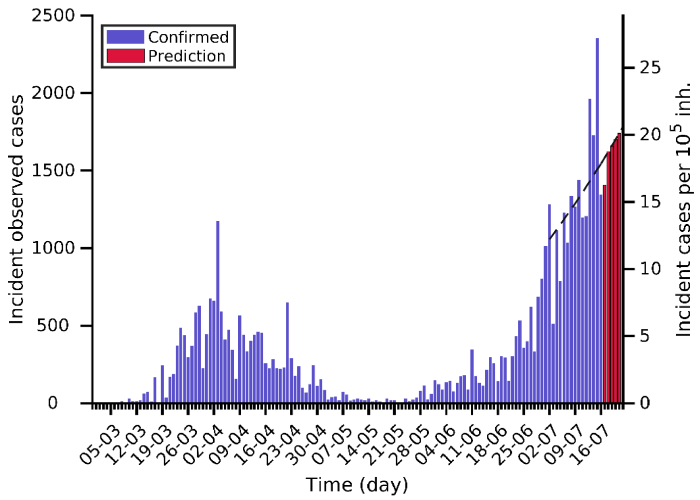


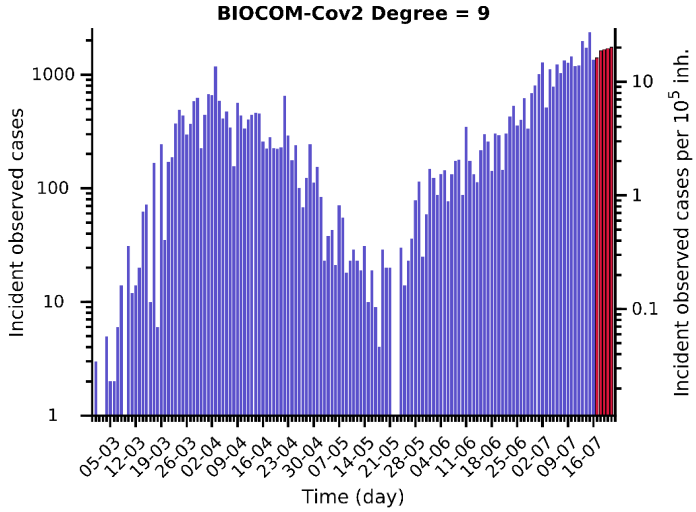


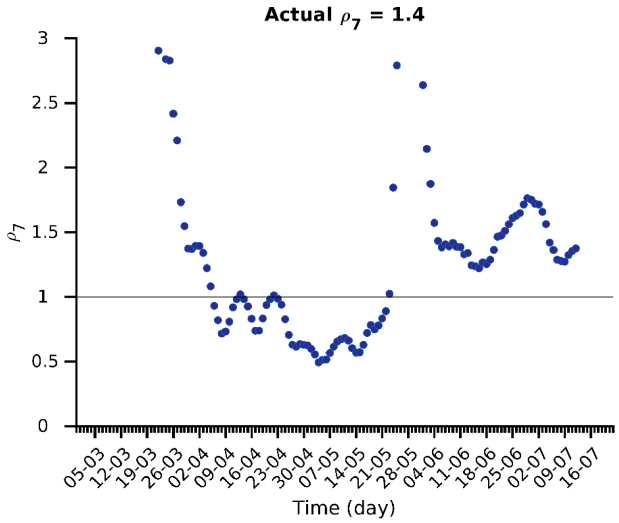
Israel 16-07-2020. Pop: 8.7M. Cumulative incidence: 532/10⁵

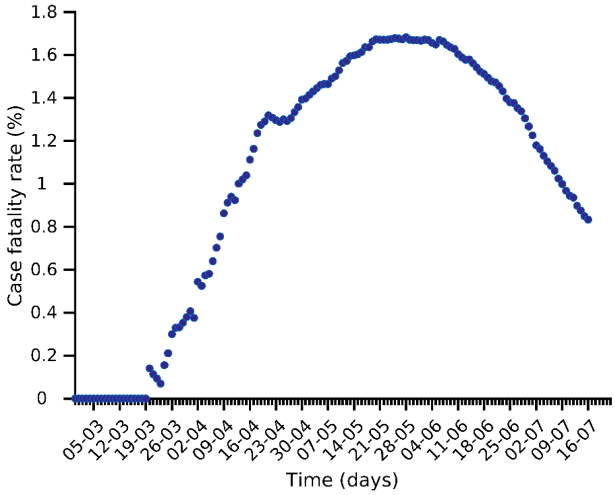


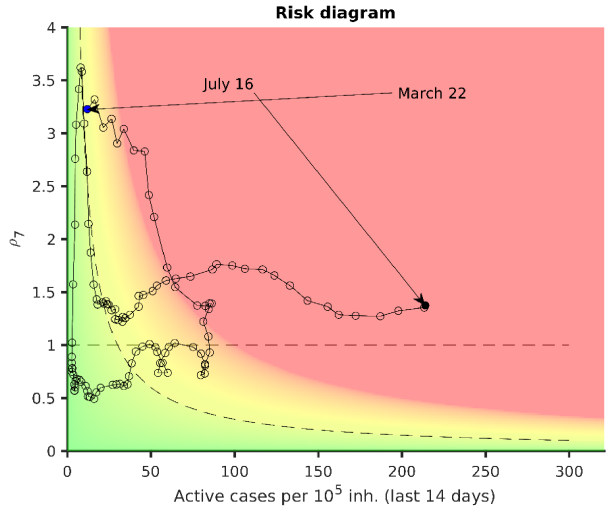


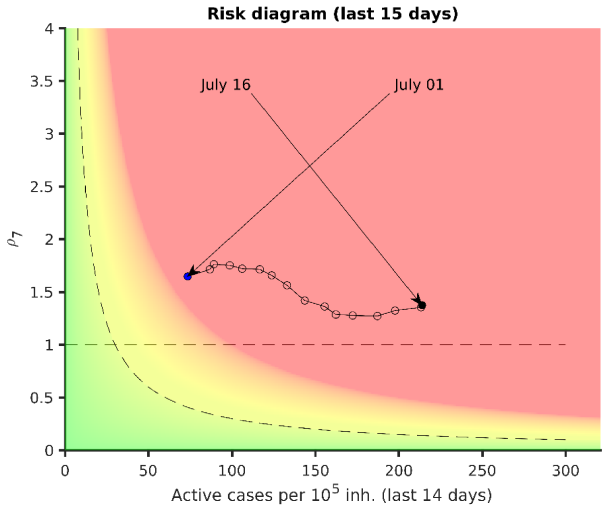




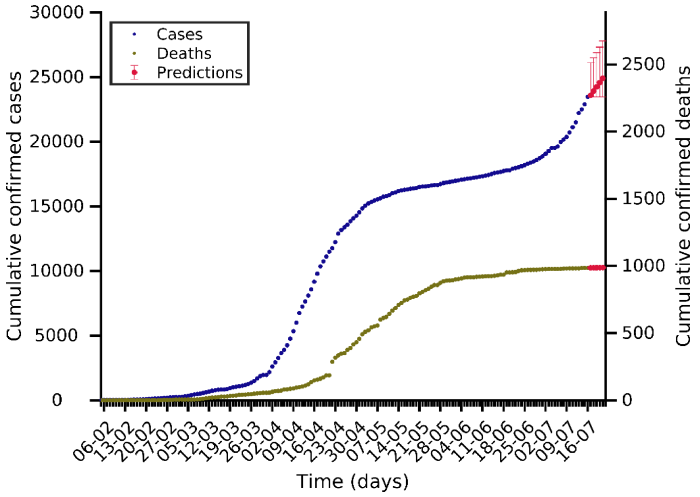


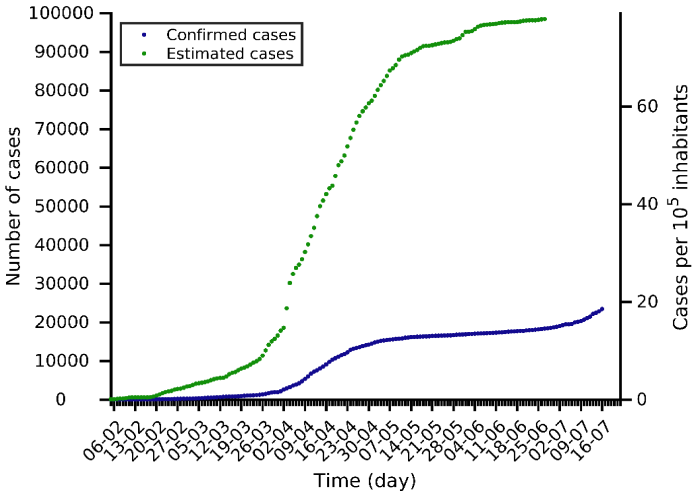


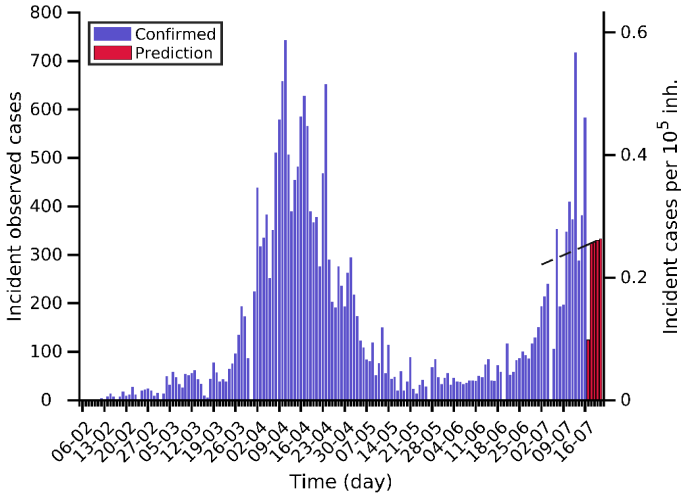


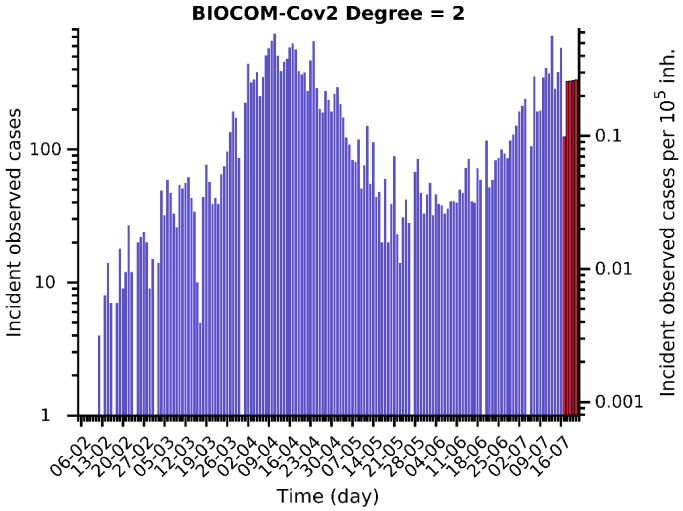


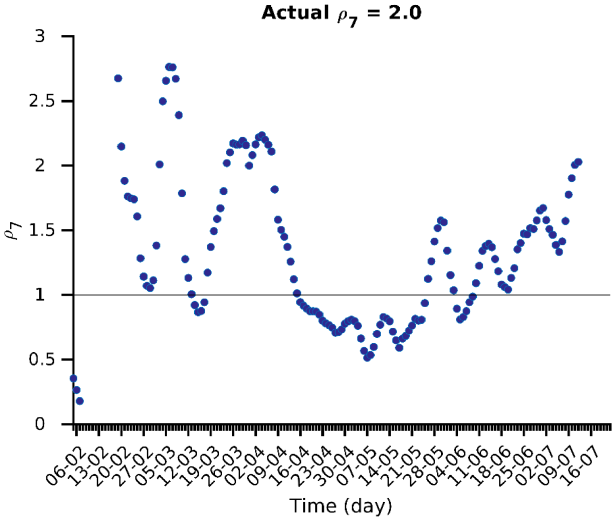
Japan 16-07-2020. Pop: 126.5M. Cumulative incidence: 19/10^5

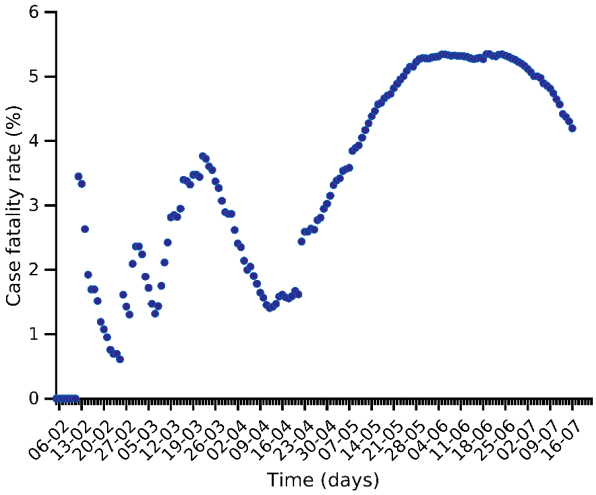


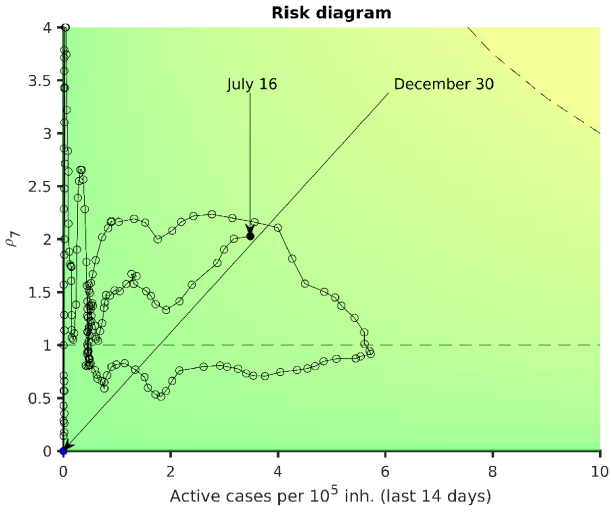


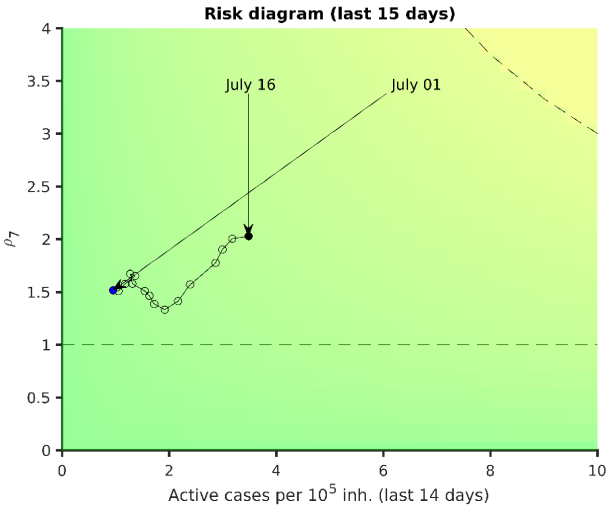




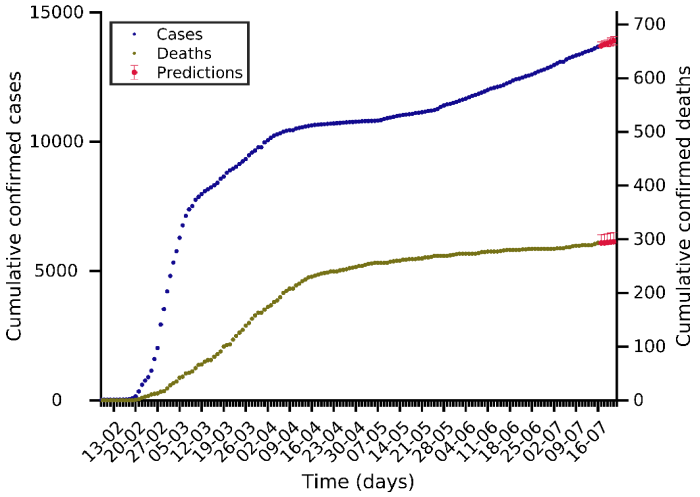


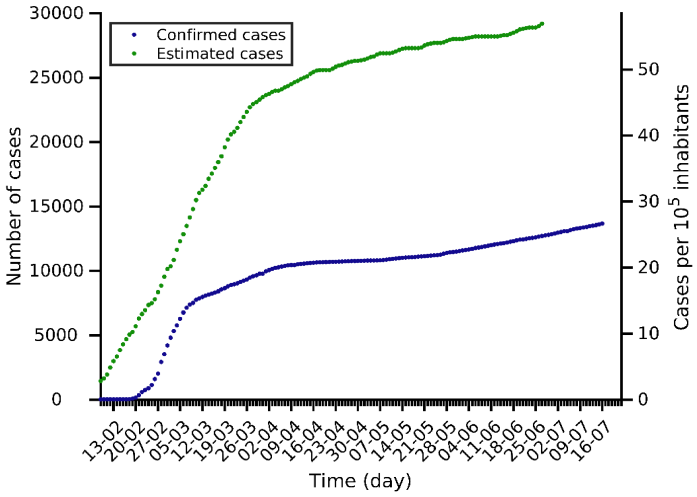


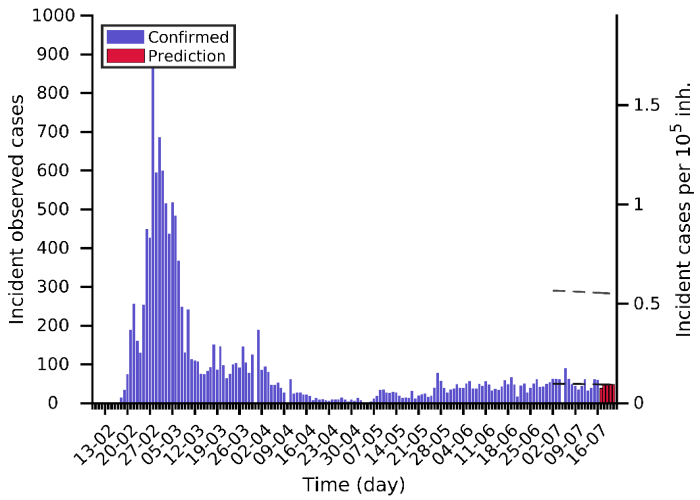


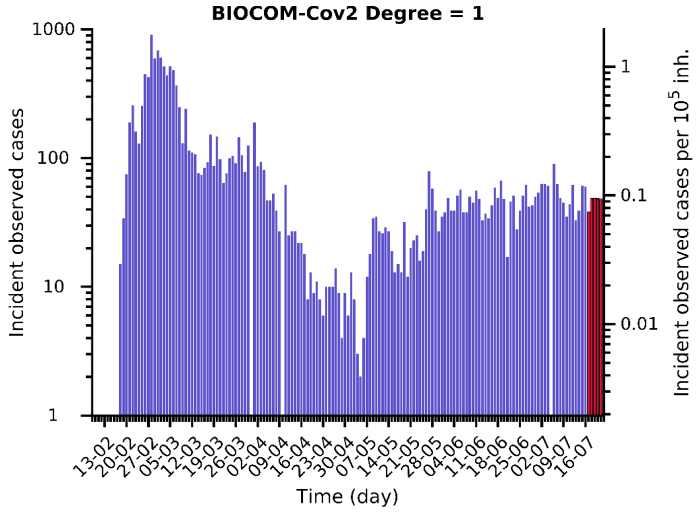


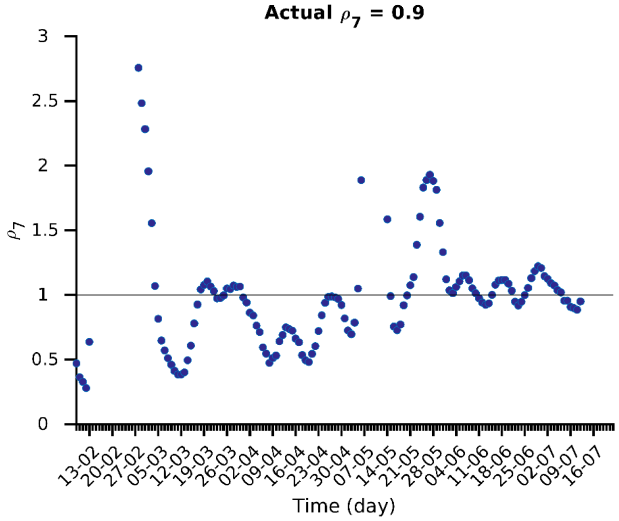
South Korea 16-07-2020. Pop: 51.3M. Cumulative incidence: 27/10^5

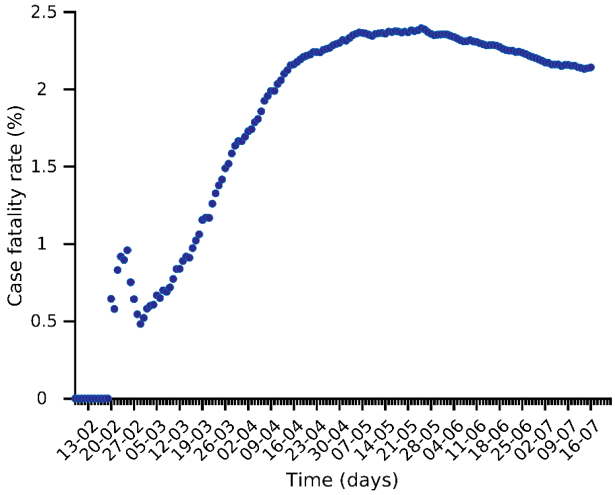


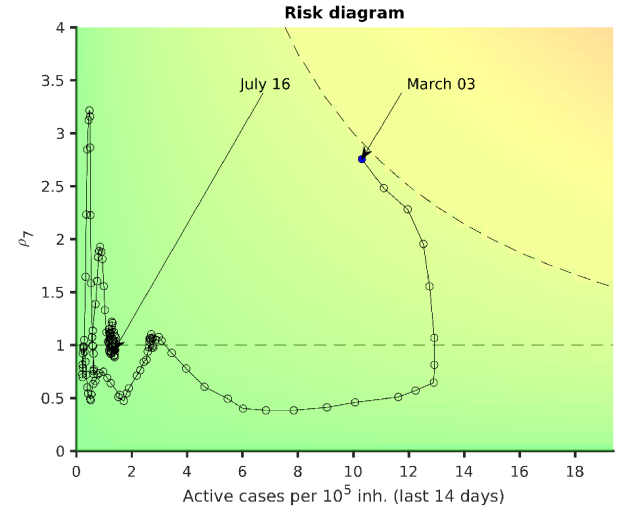


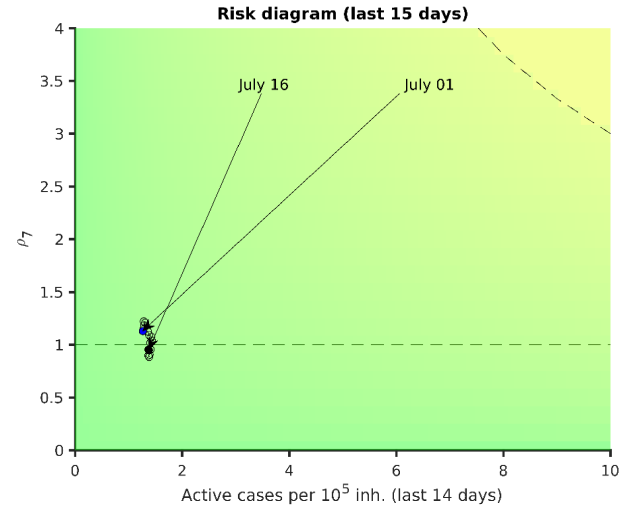




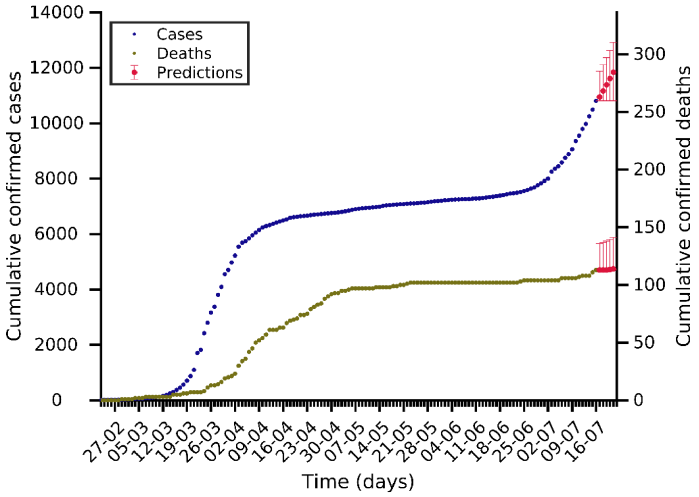


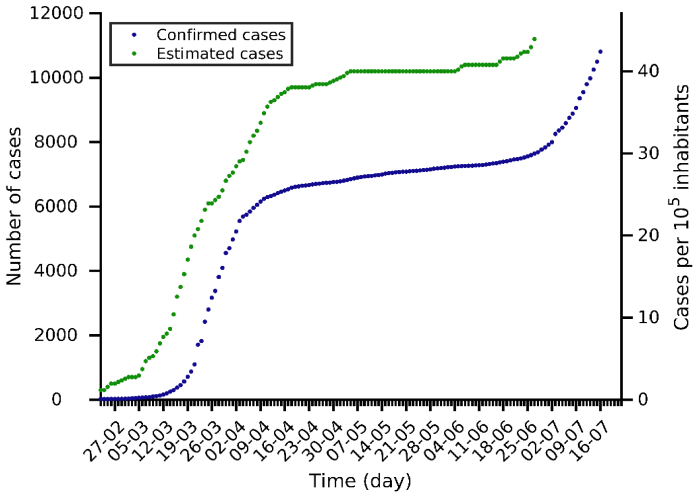


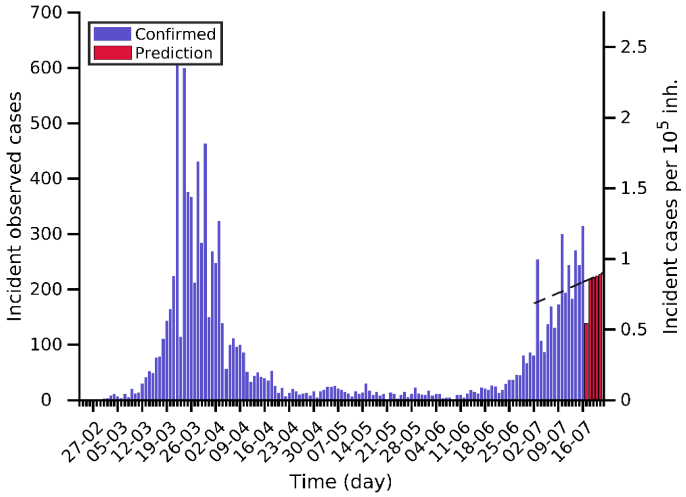


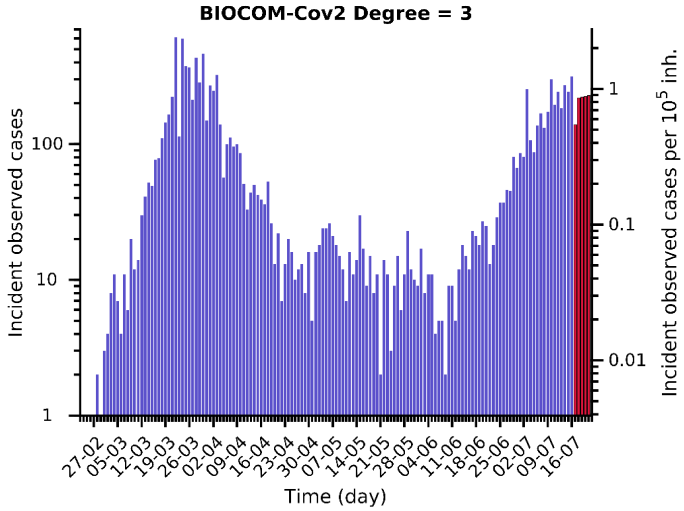


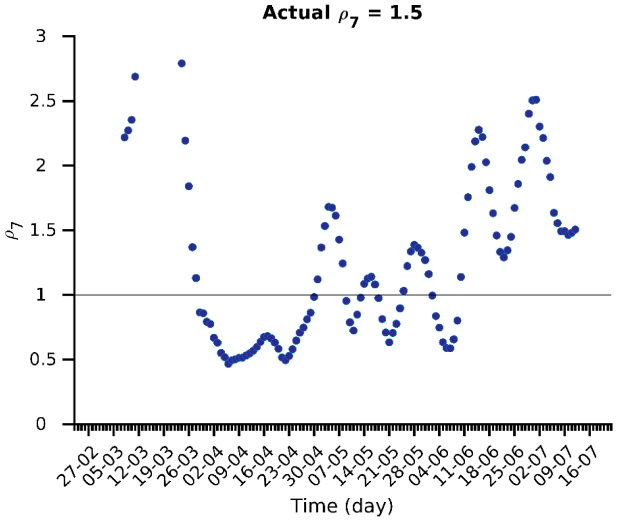
Australia 16-07-2020. Pop: 25.5M. Cumulative incidence: 42/10⁵

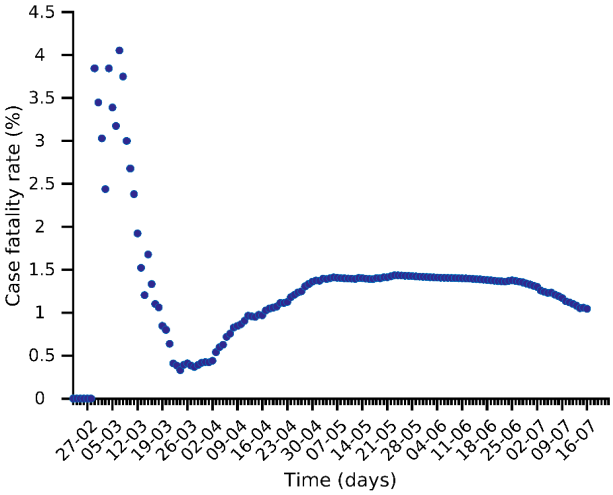


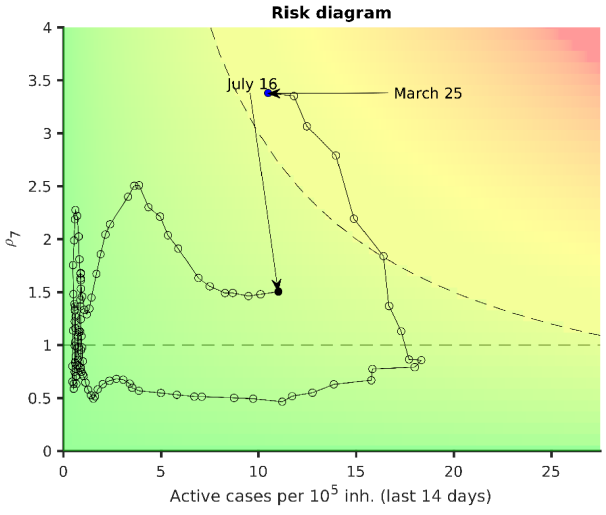


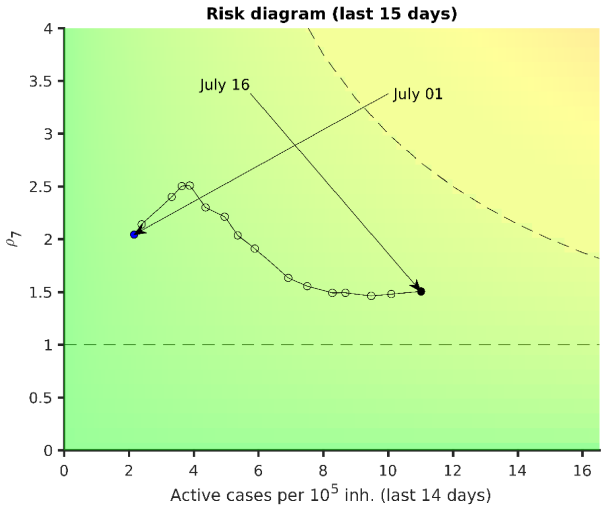




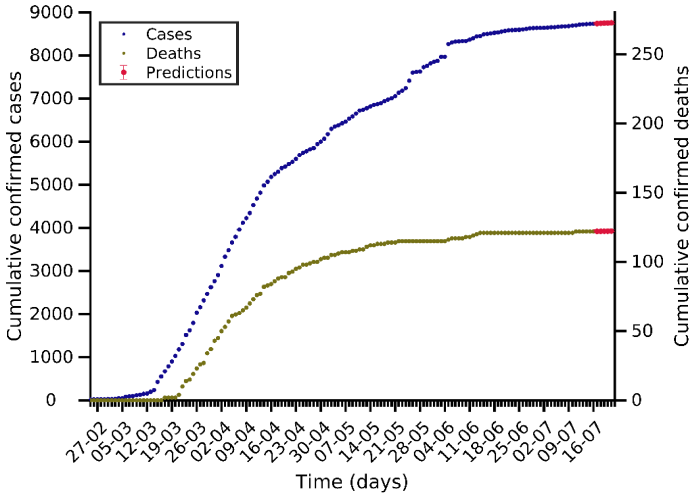


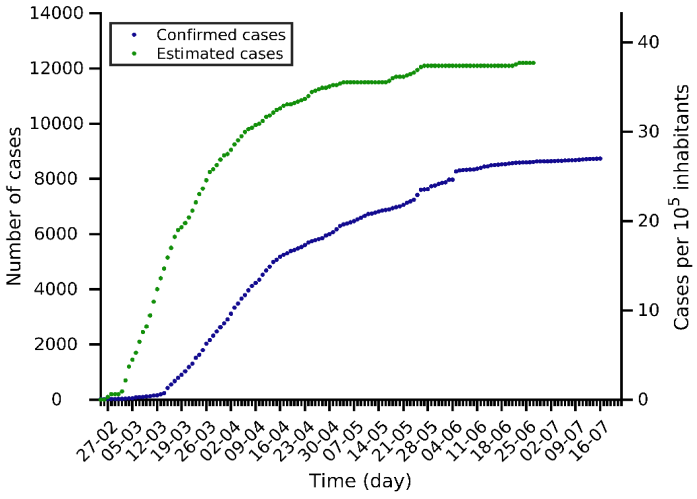


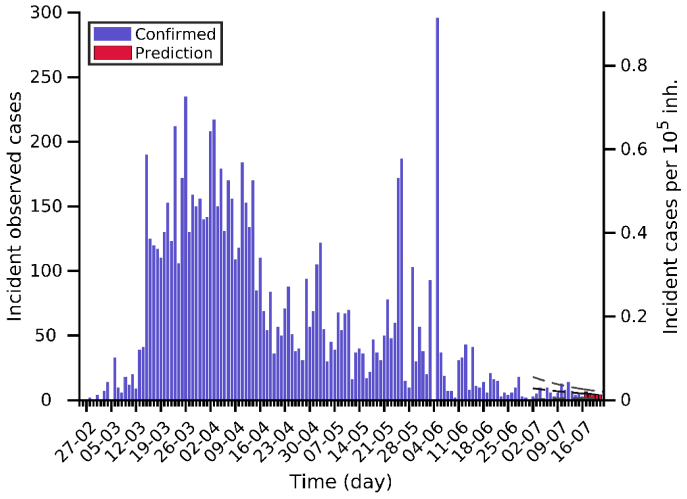


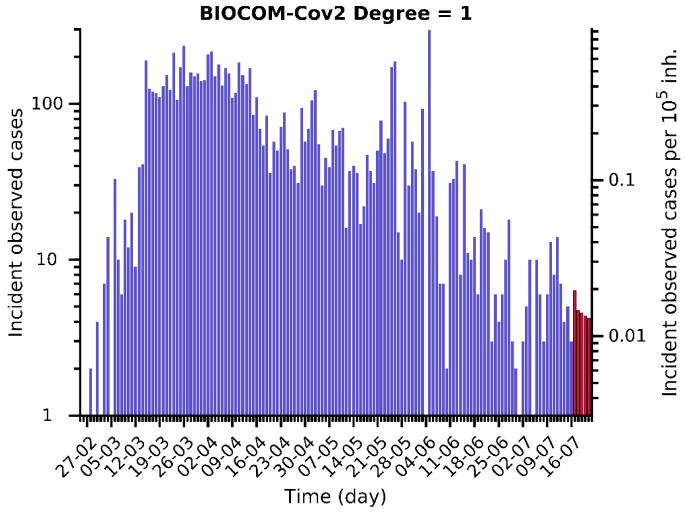


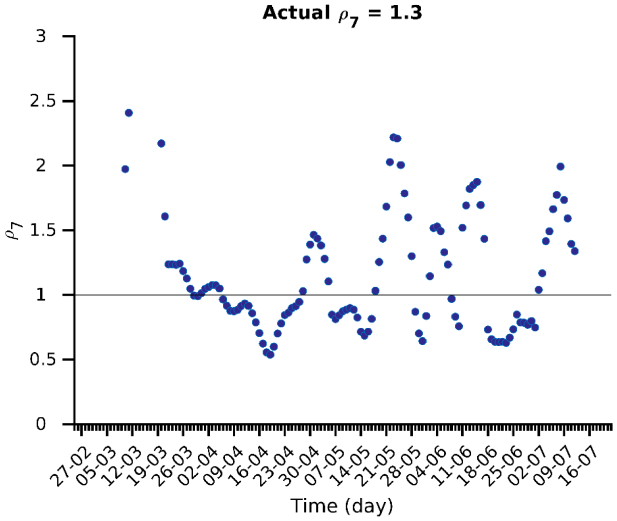
Malaysia 16-07-2020. Pop: 32.4M. Cumulative incidence: 27/10^5

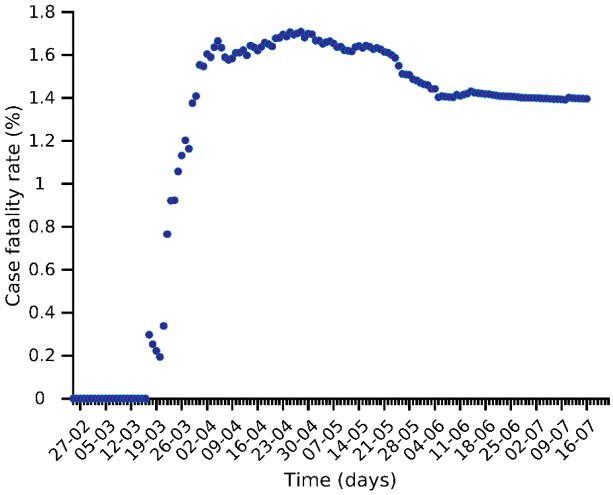


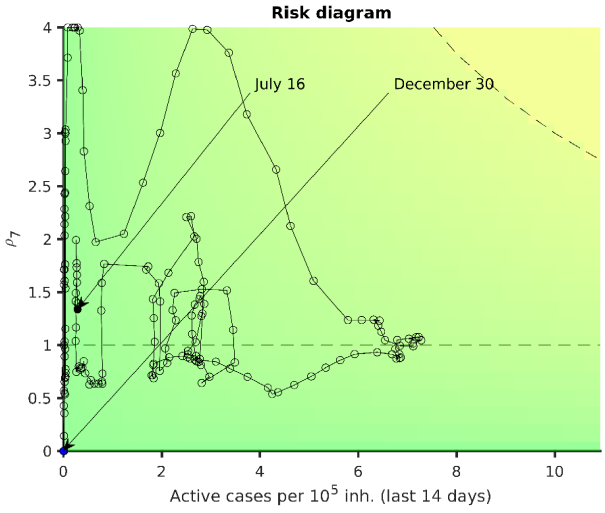


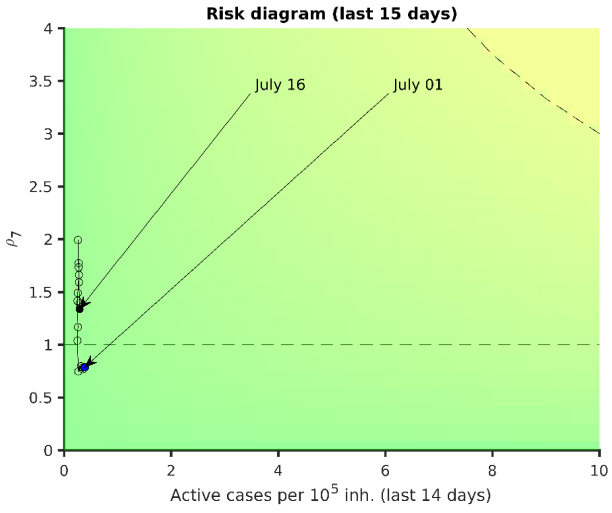




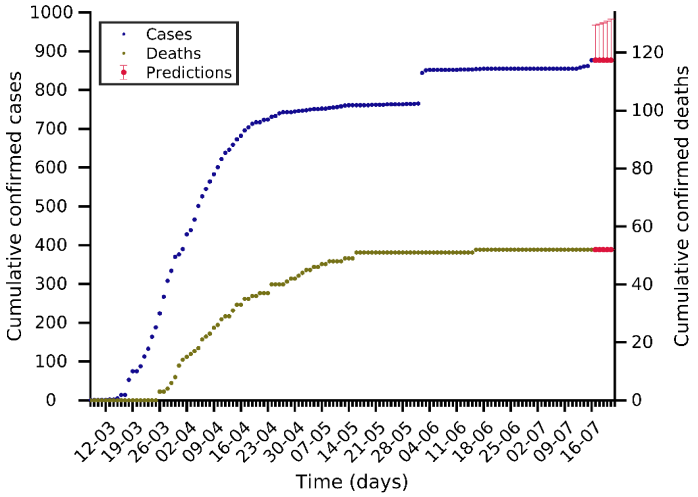


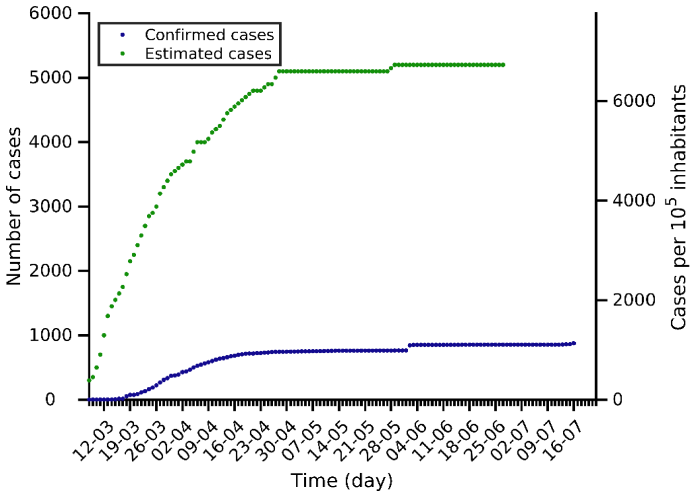


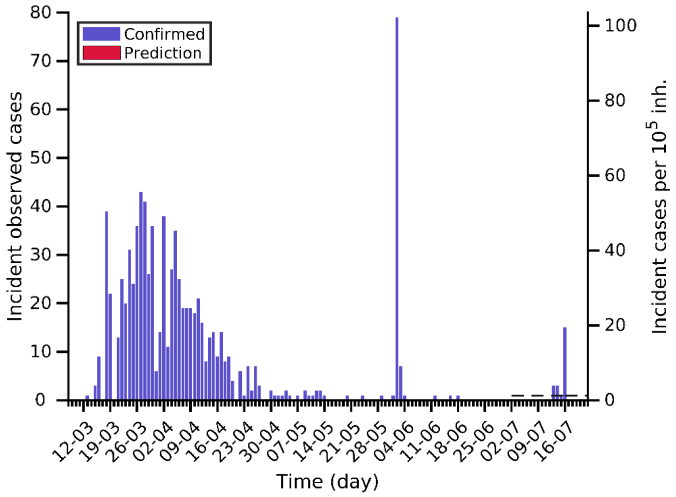


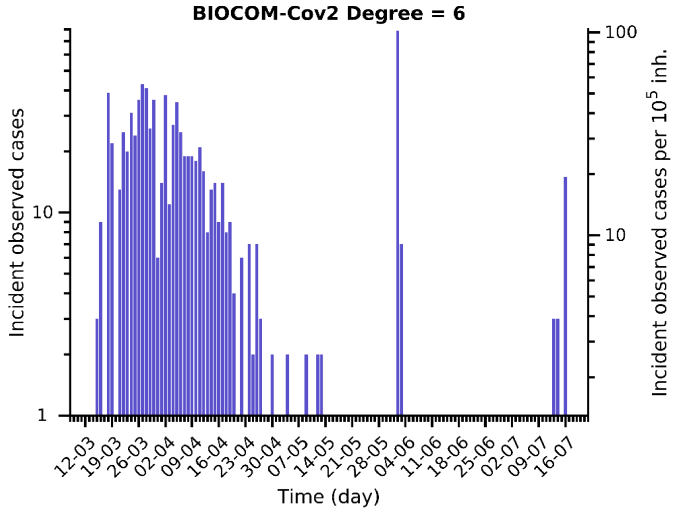


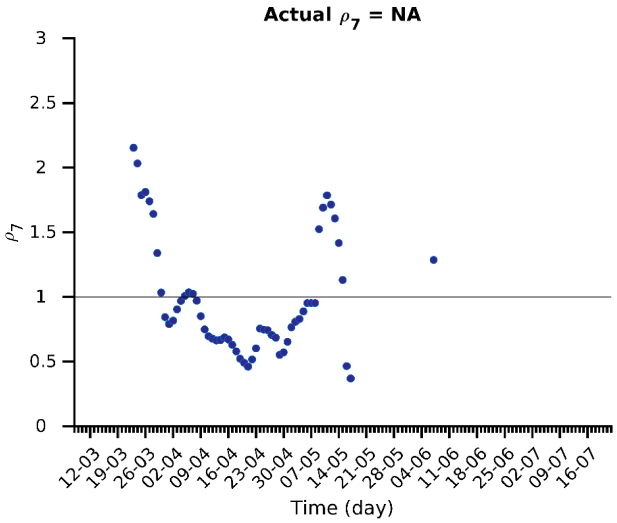
Andorra 16-07-2020. Pop: 0.1M. Cumulative incidence: 1135/10^5

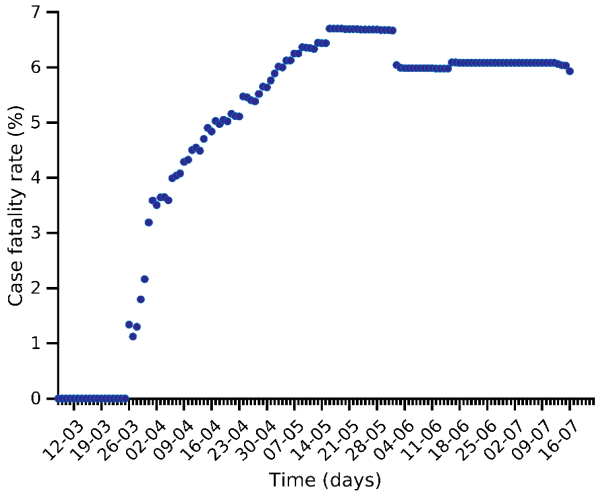


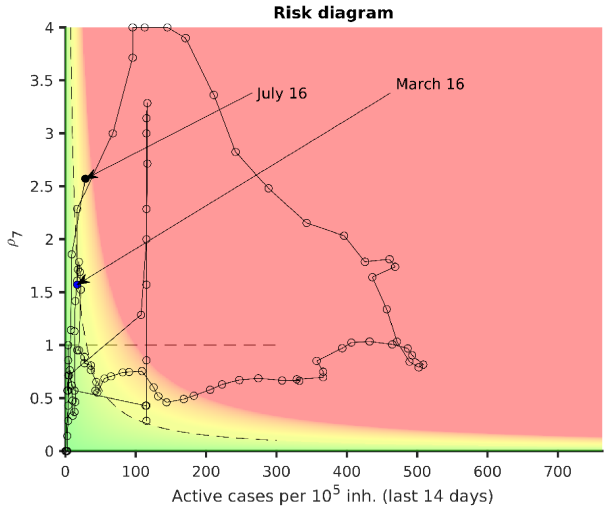


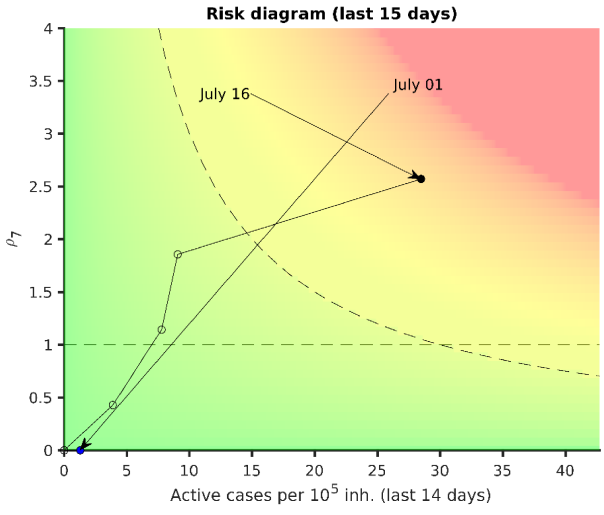










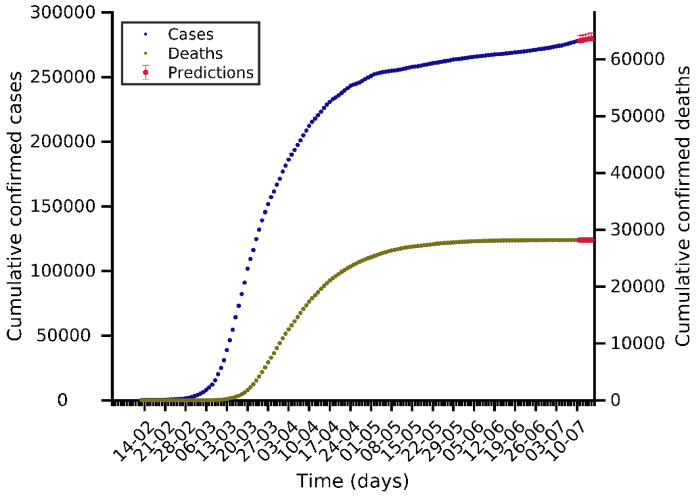


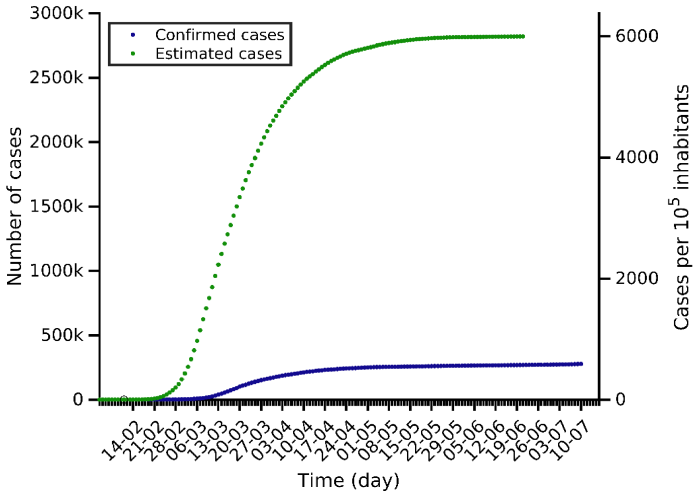
(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities

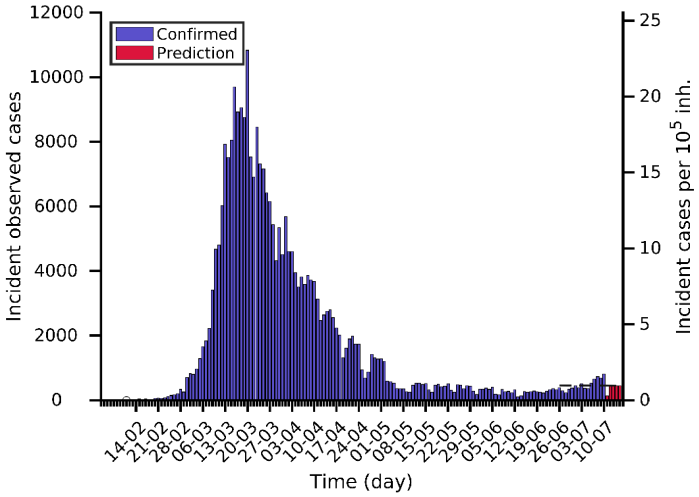
Data updated on 17th July, data series built with the day of the symptoms' onset, reliable until 10th July.

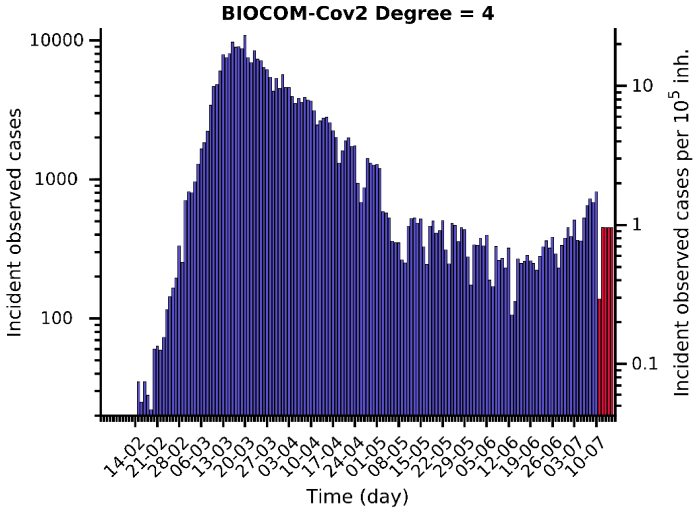
Data obtained from https://github.com/datadista/datasets/tree/master/COVID%2019 and https://covid19.isciii.es/

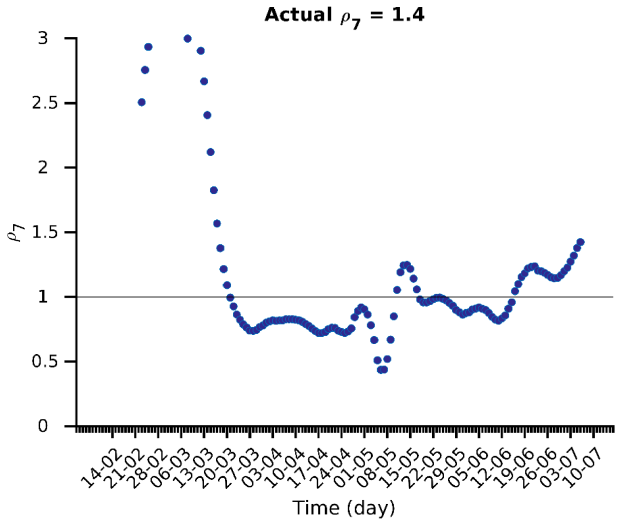
Spain 10-07-2020. Pop: 47.0M. Cumulative incidence: 591/10⁵

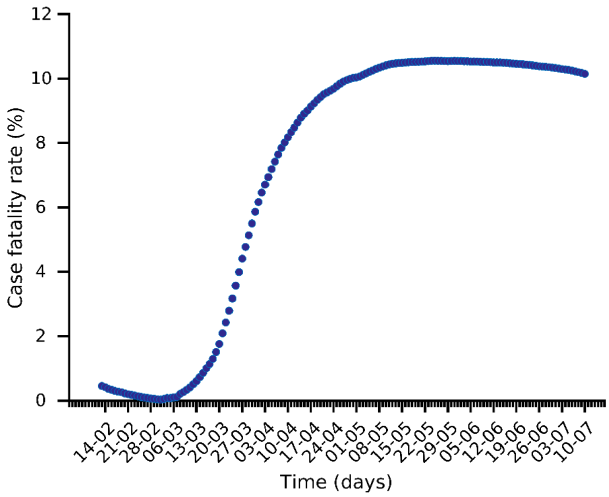


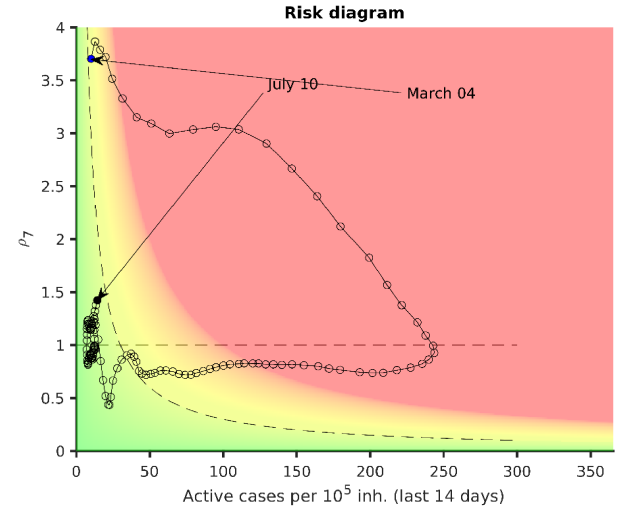


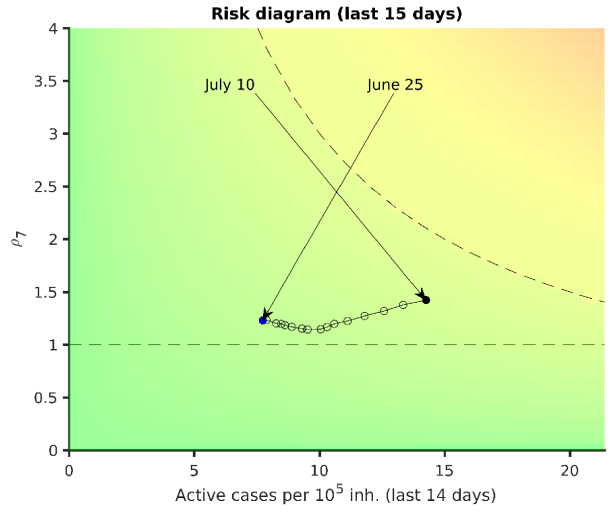




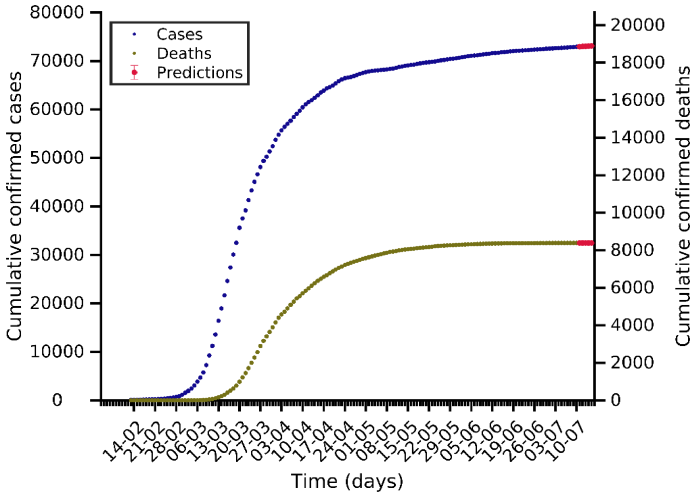


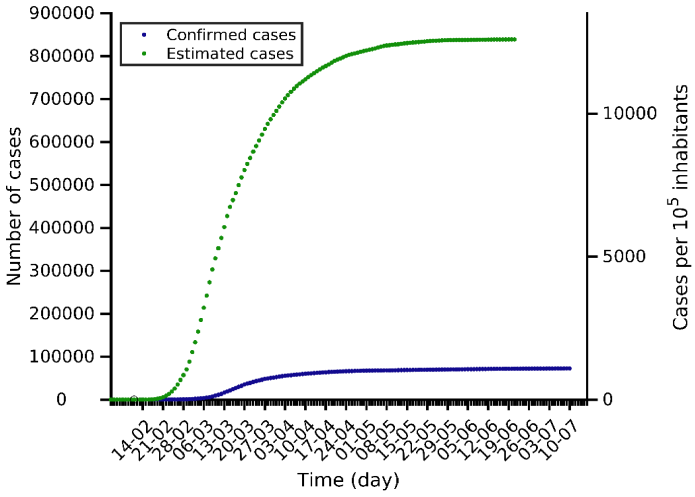


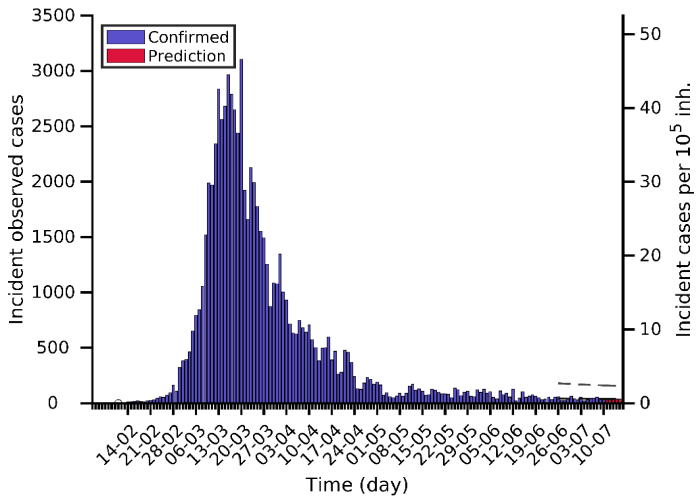


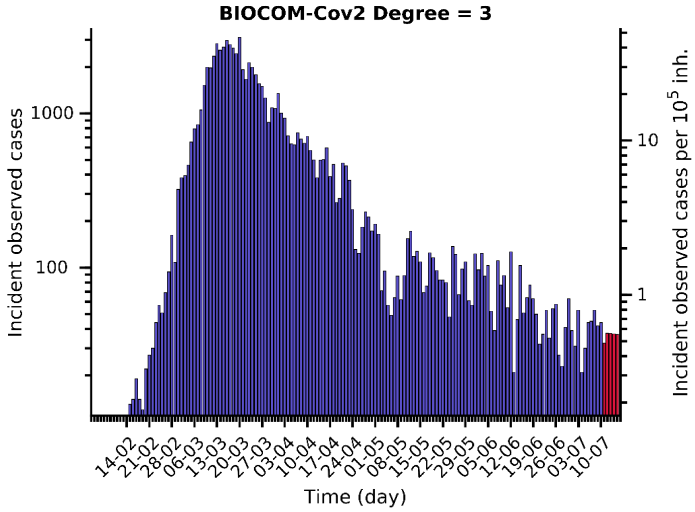


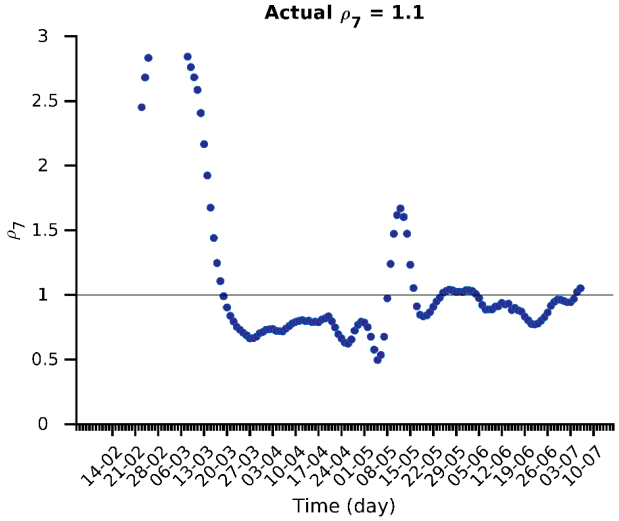
Madrid 10-07-2020. Pop: 6.7M. Cumulative incidence: 1094/10⁵

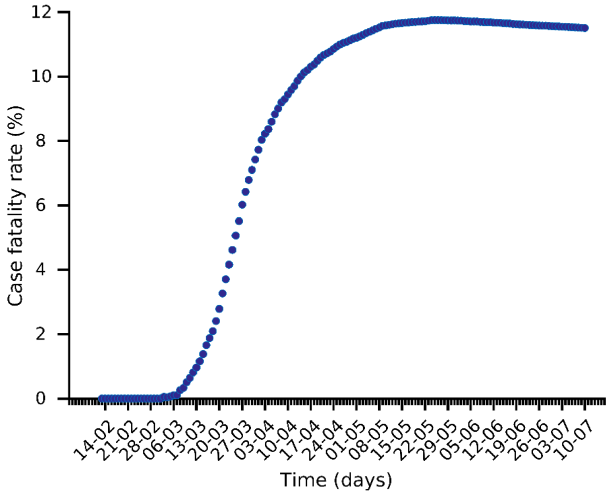


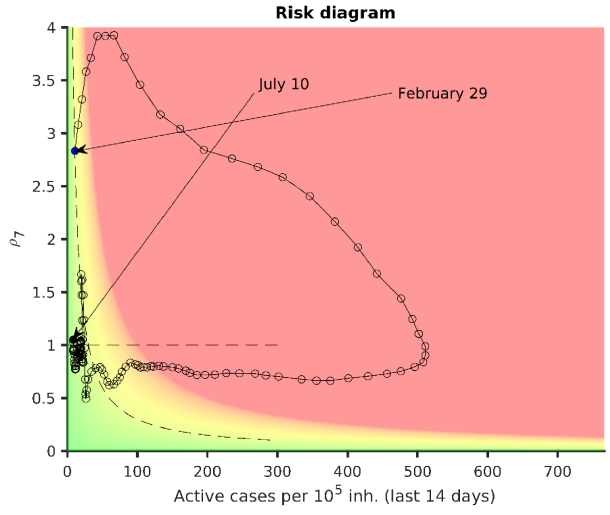


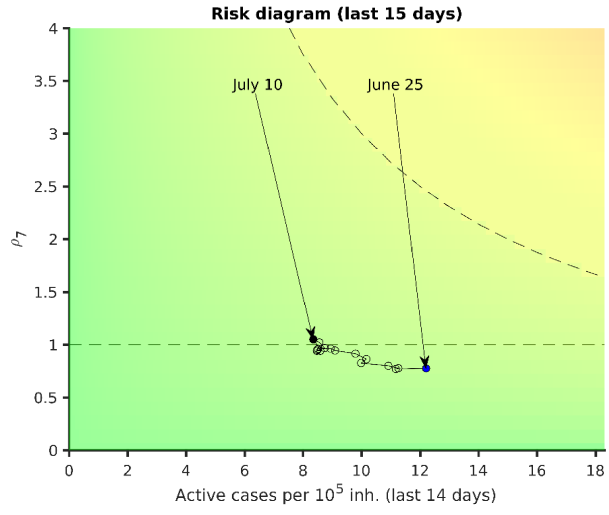




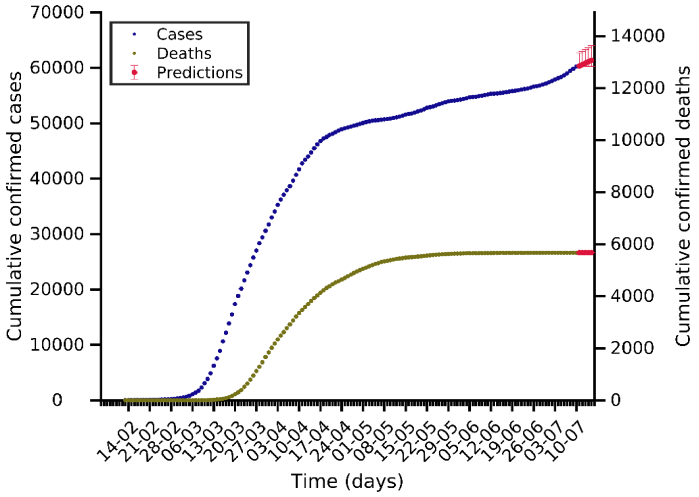


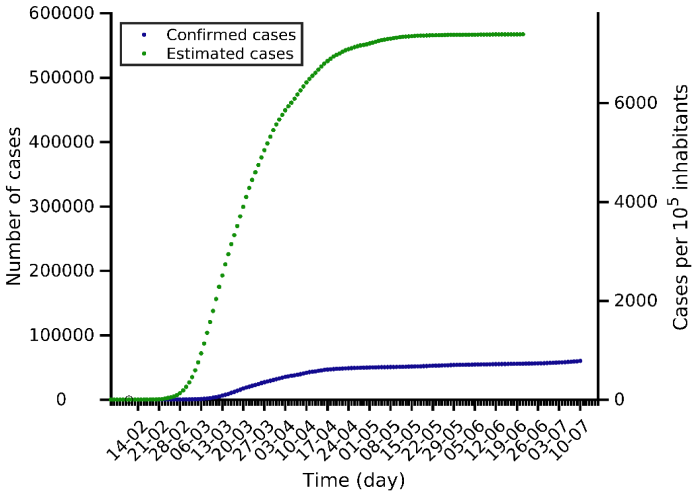


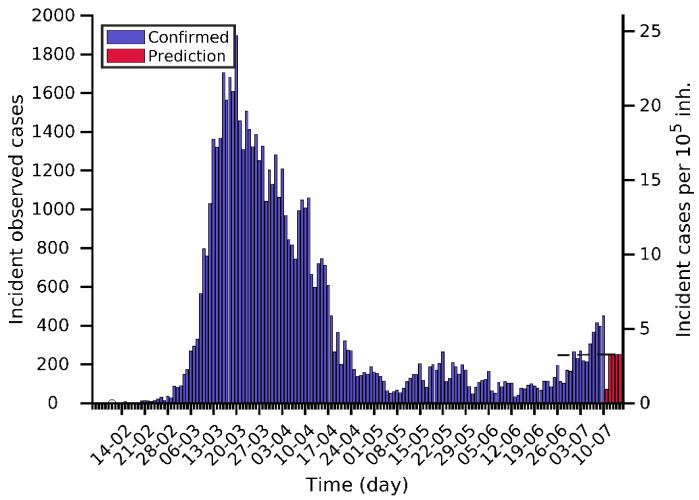


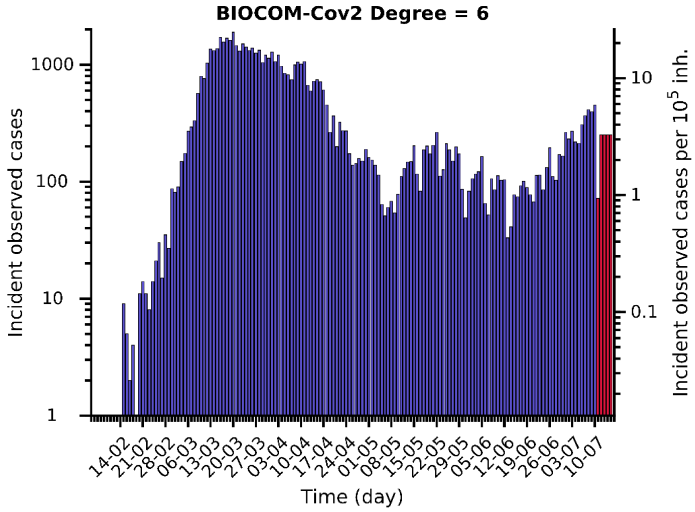


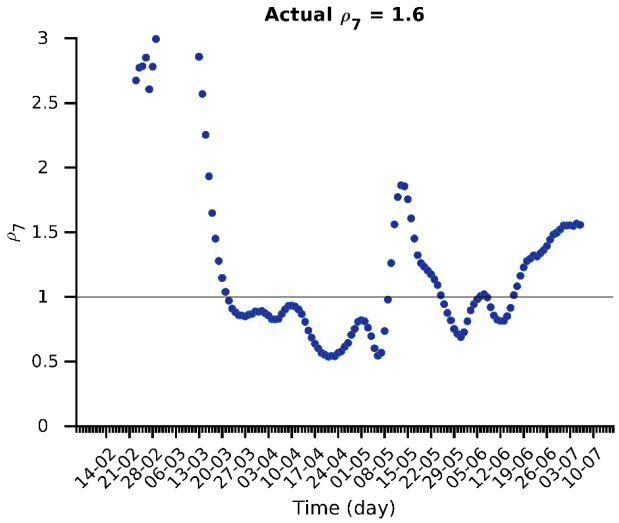
Catalunya 10-07-2020. Pop: 7.7M. Cumulative incidence: 785/10⁵

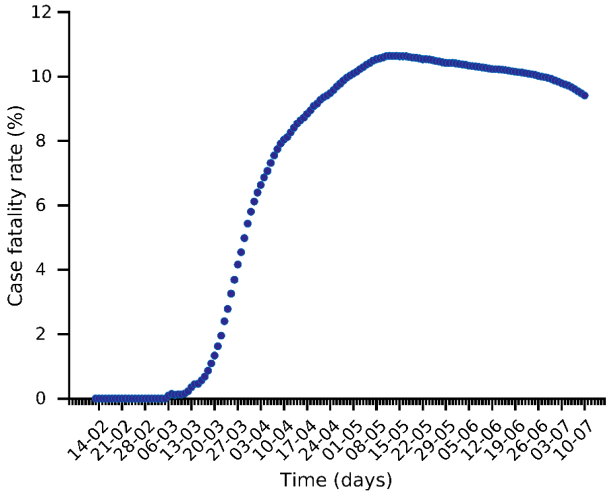


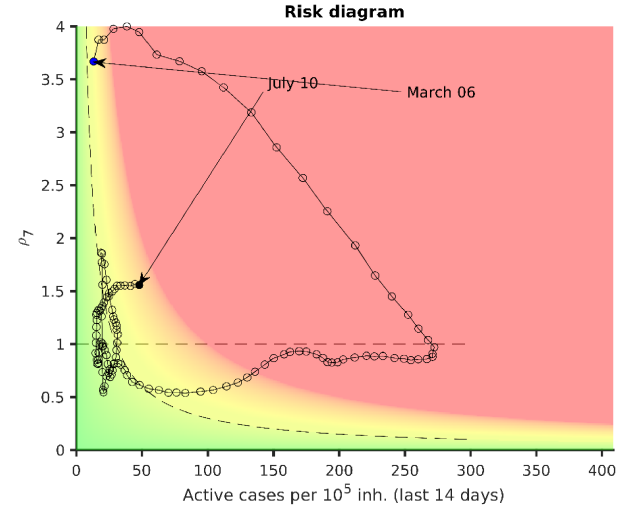


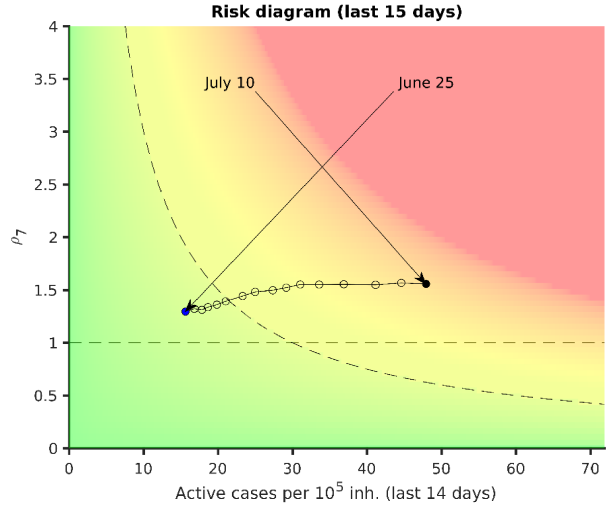




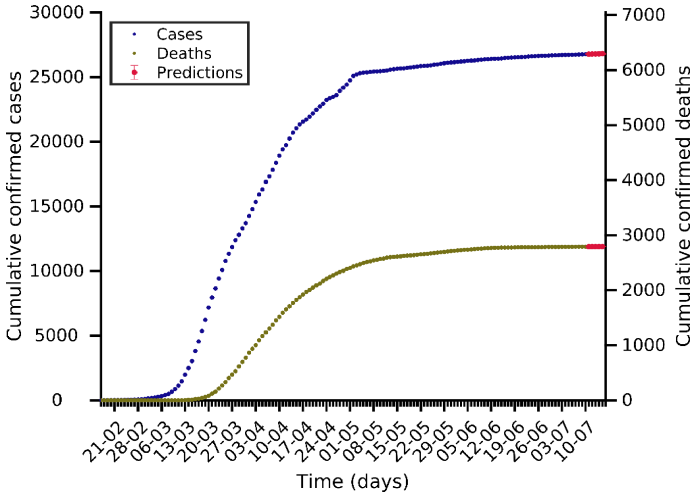


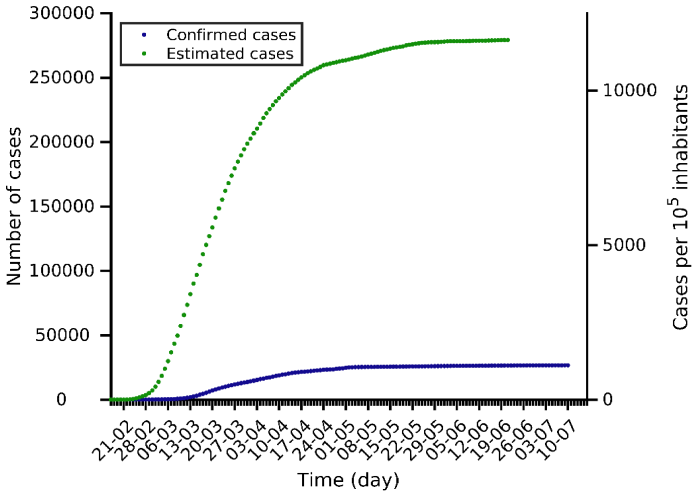


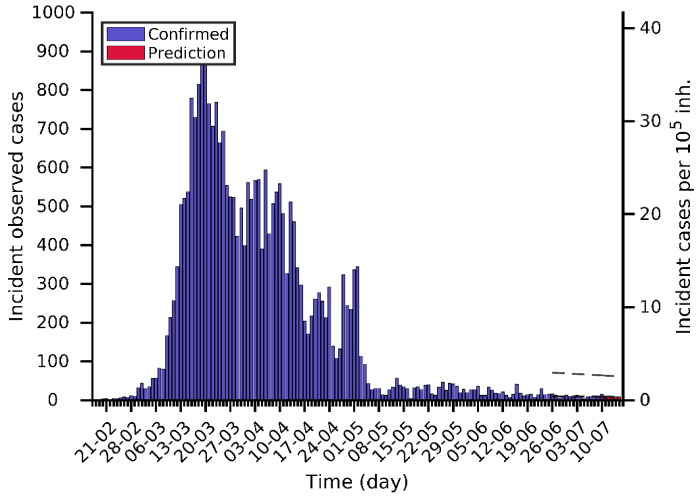


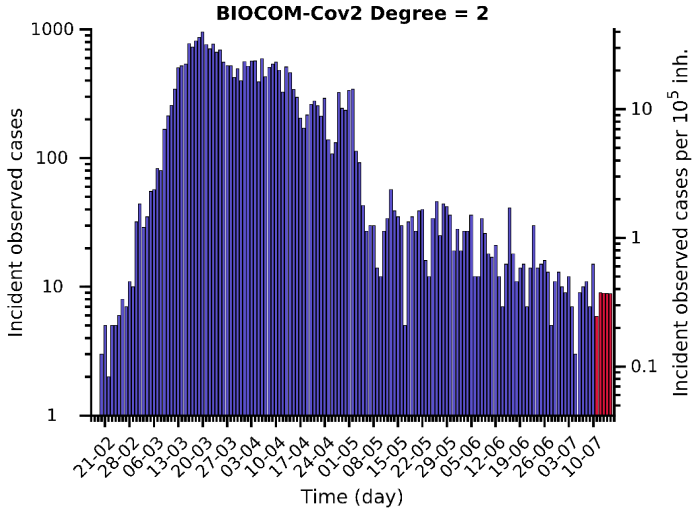


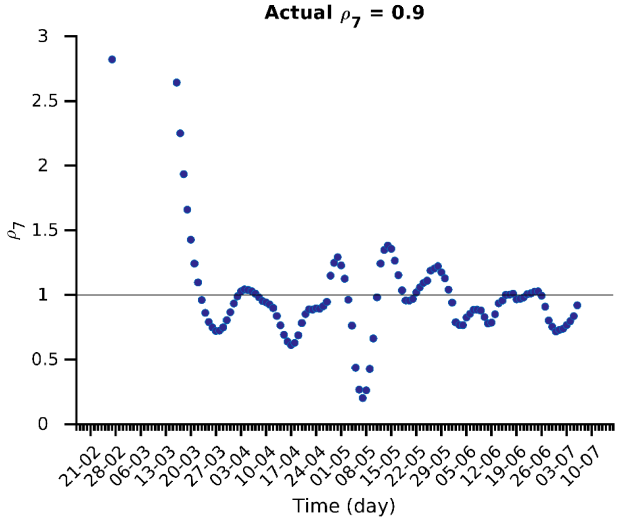
Castilla Leon 10-07-2020. Pop: 2.4M. Cumulative incidence: 1116/10^5

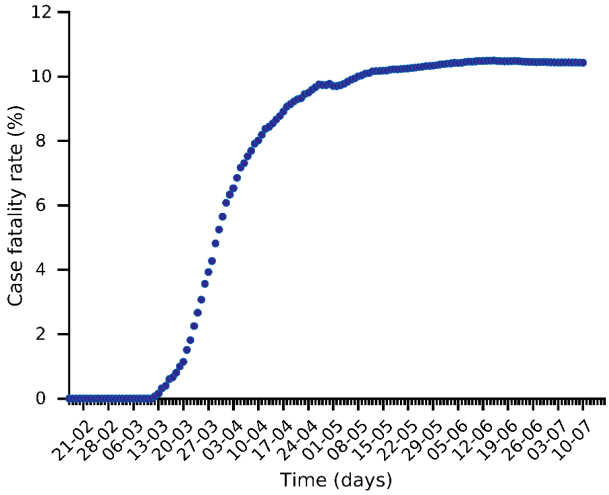


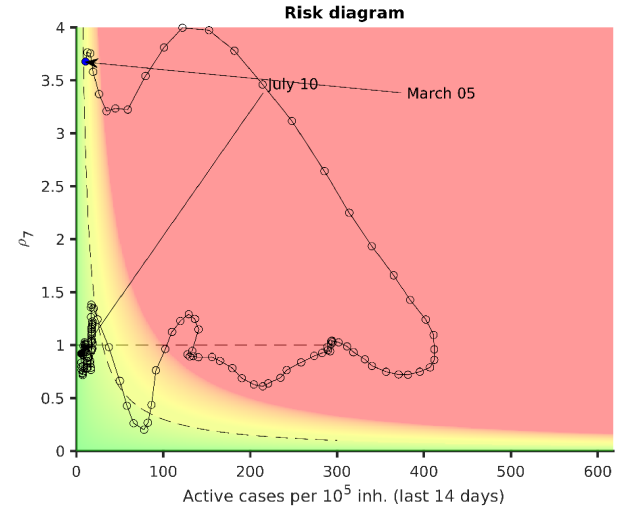


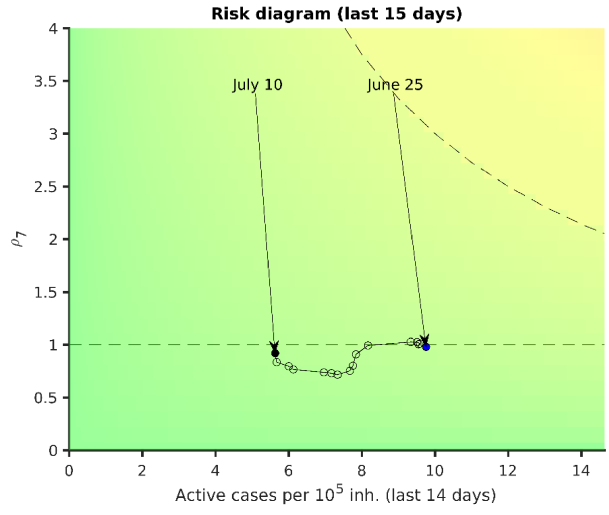




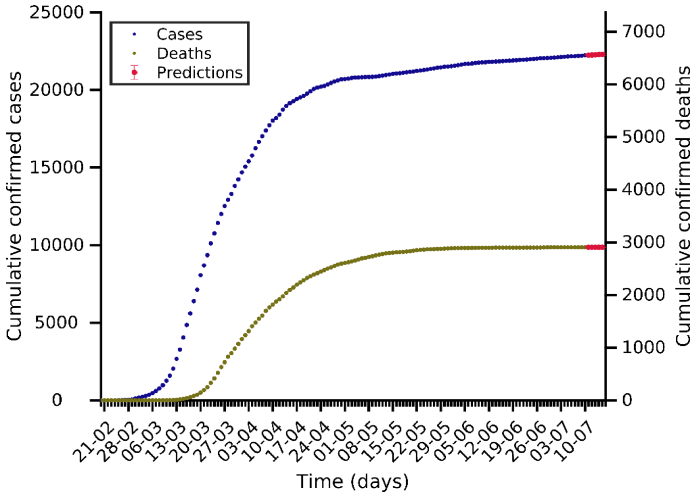


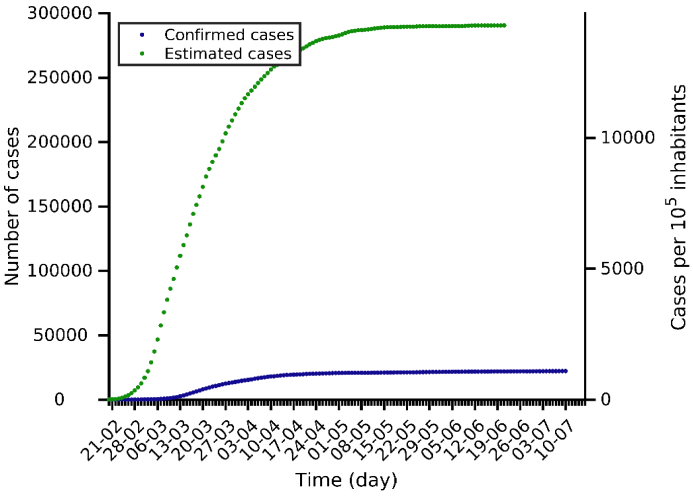


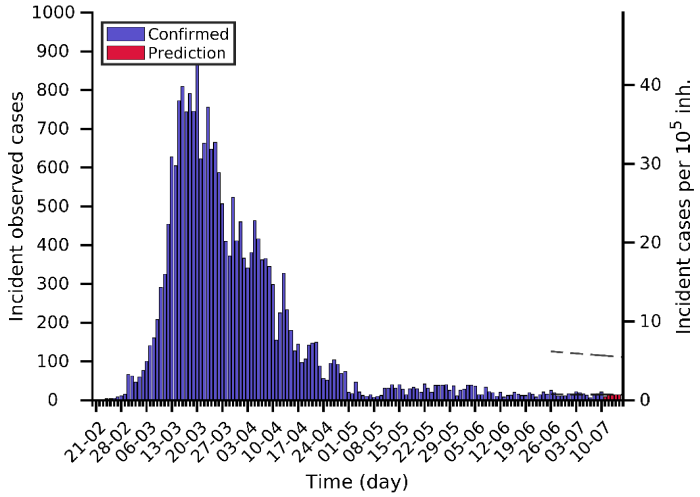


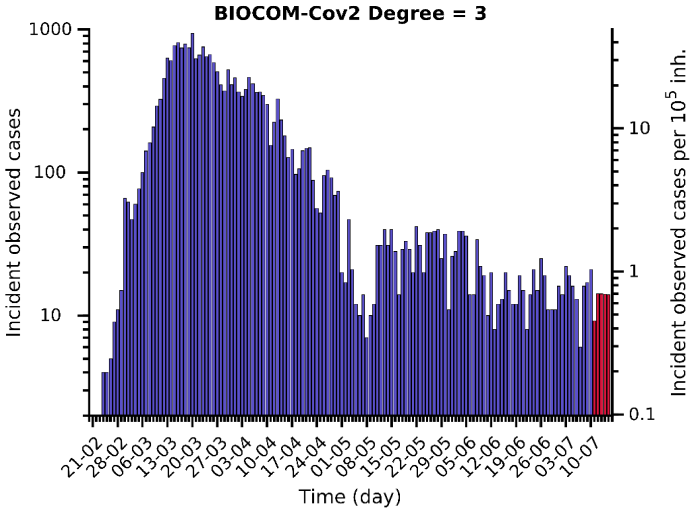


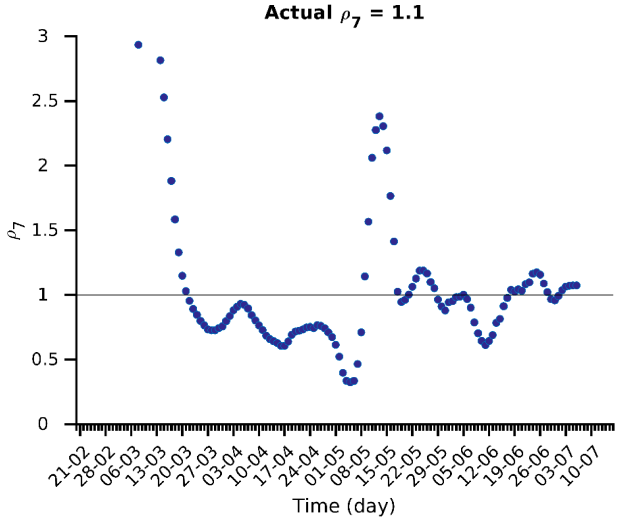
Castilla-La Mancha 10-07-2020. Pop: 2.0M. Cumulative incidence: 1094/10⁵

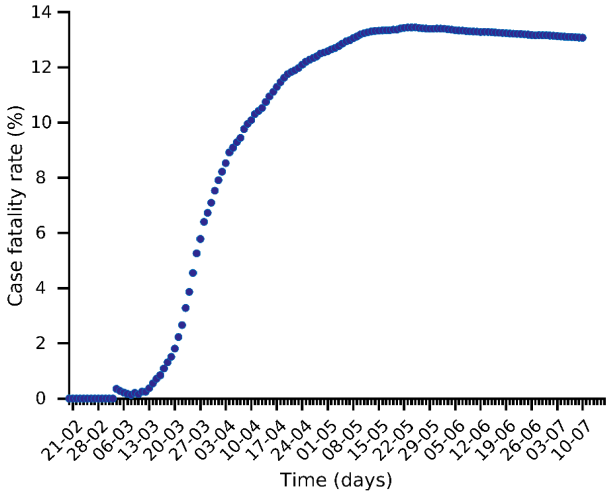


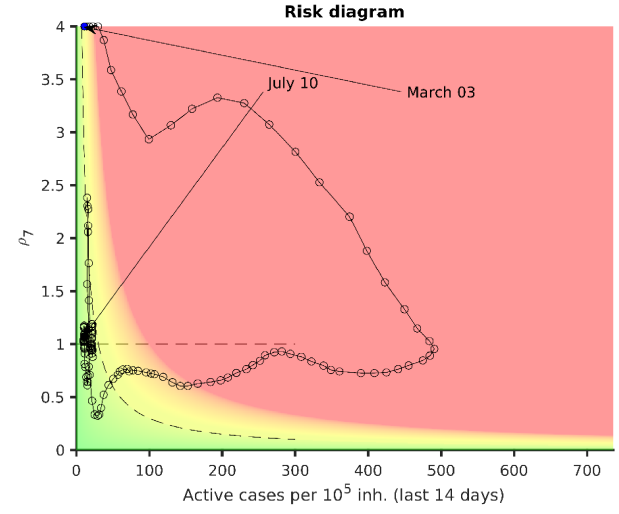


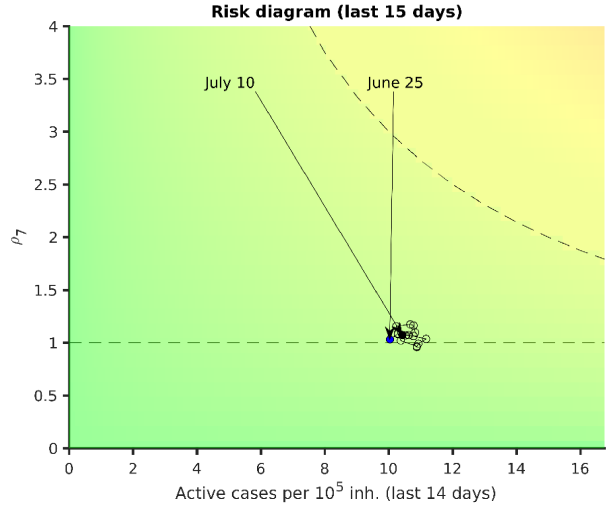




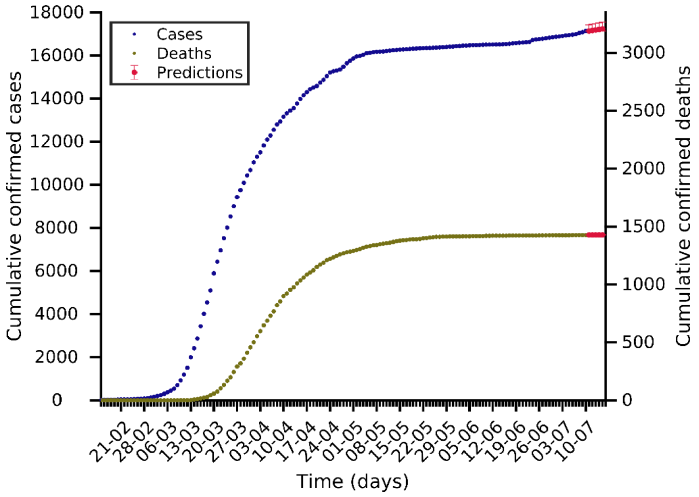


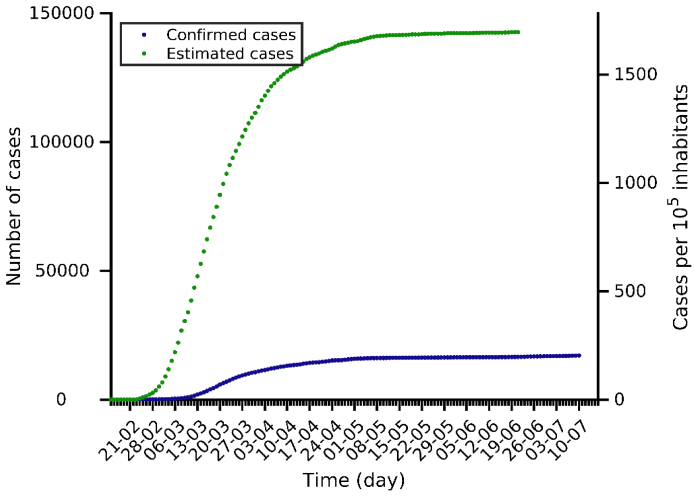


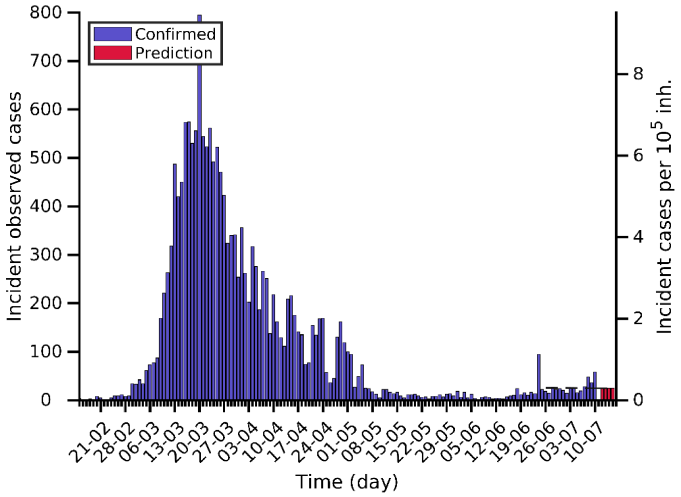


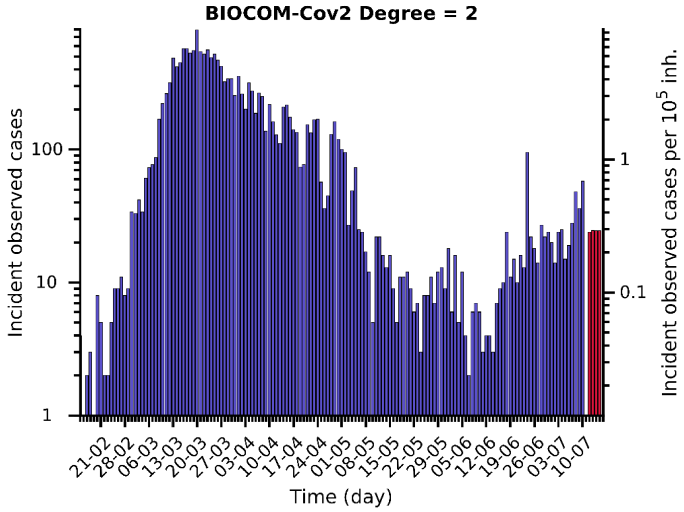


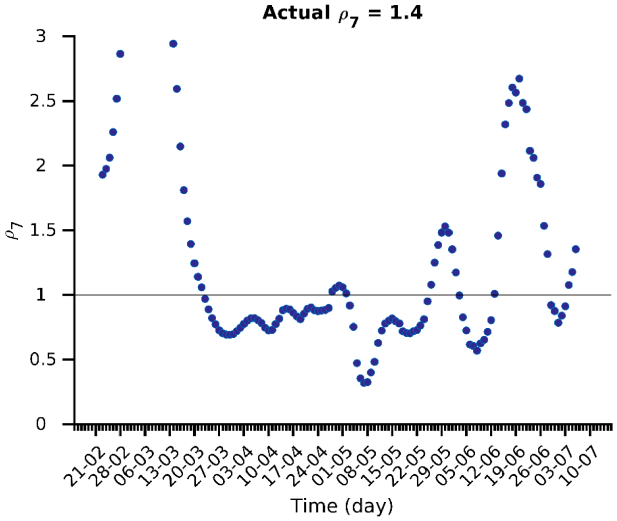
Andalucia 10-07-2020. Pop: 8.4M. Cumulative incidence: 204/10⁵

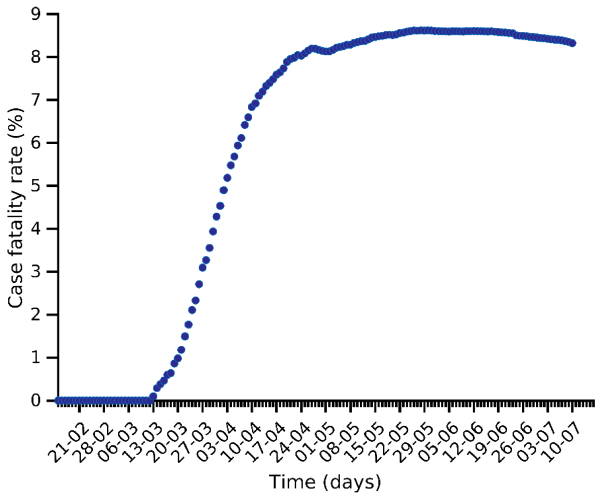


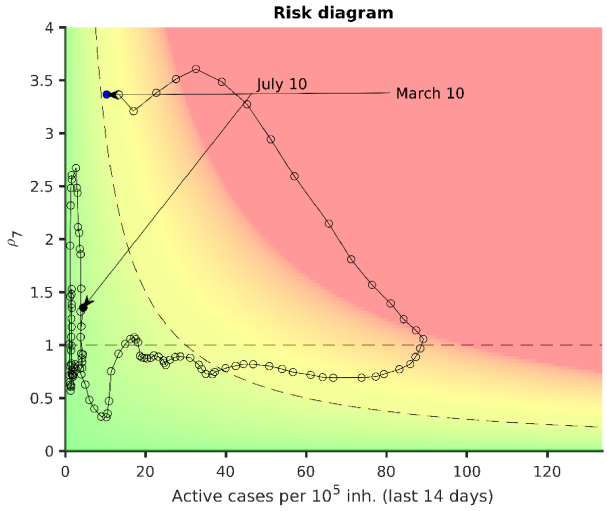


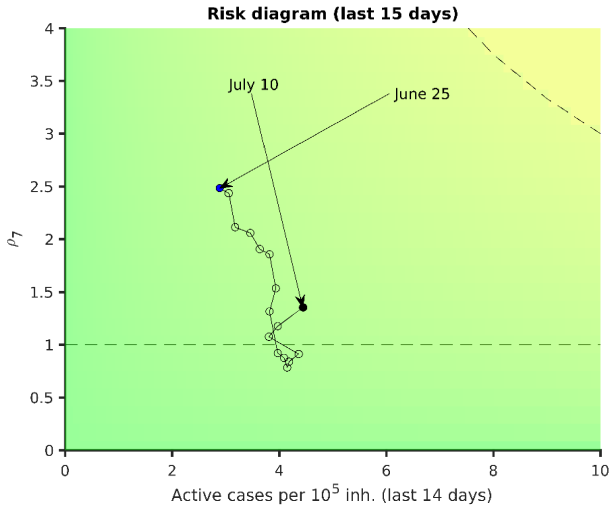




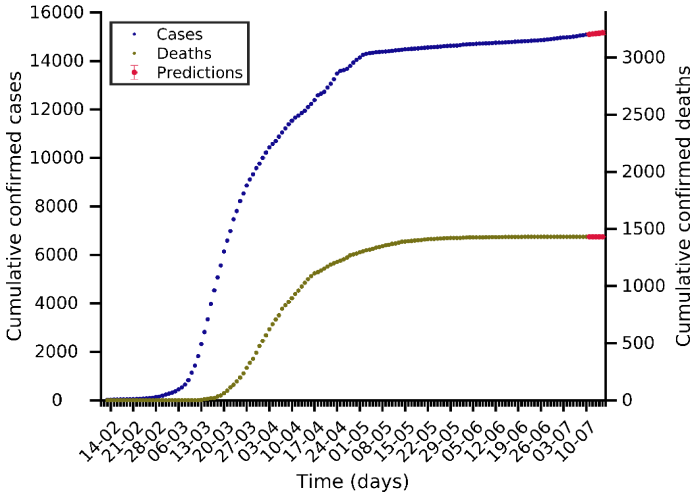


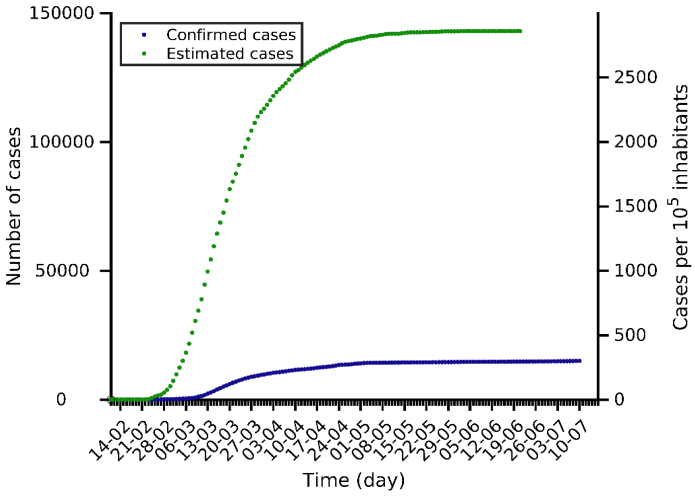


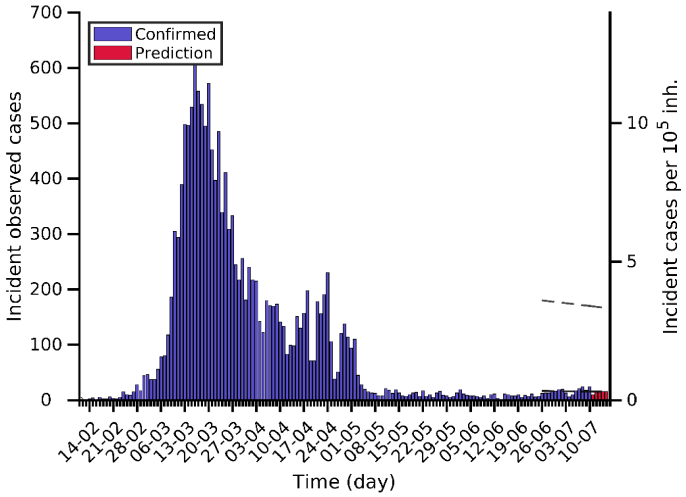


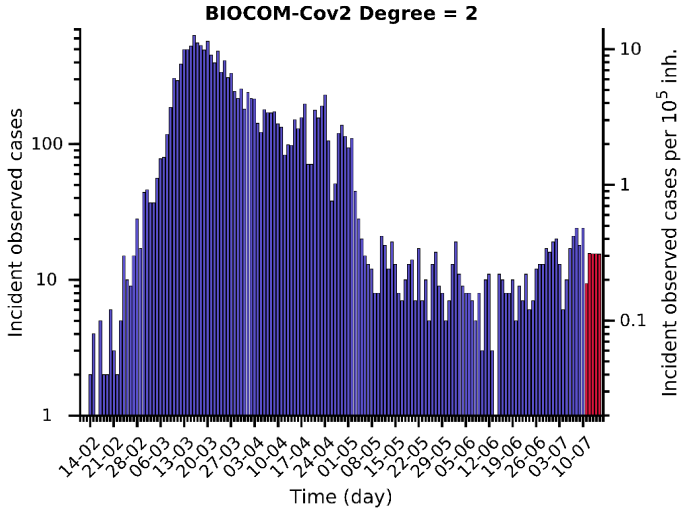


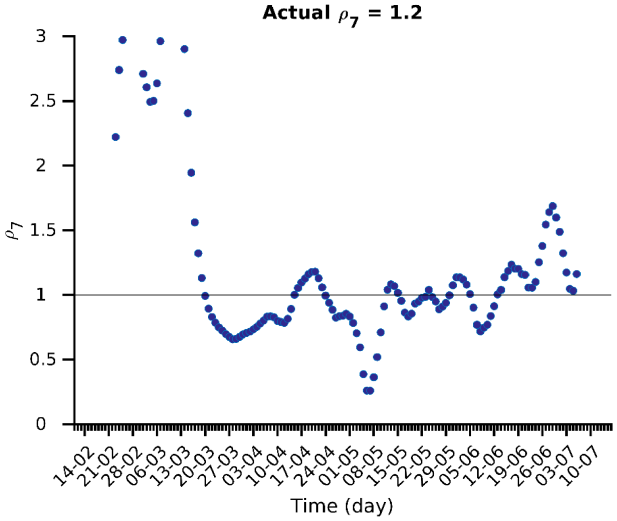
C Valenciana 10-07-2020. Pop: 5.0M. Cumulative incidence: 302/10⁵

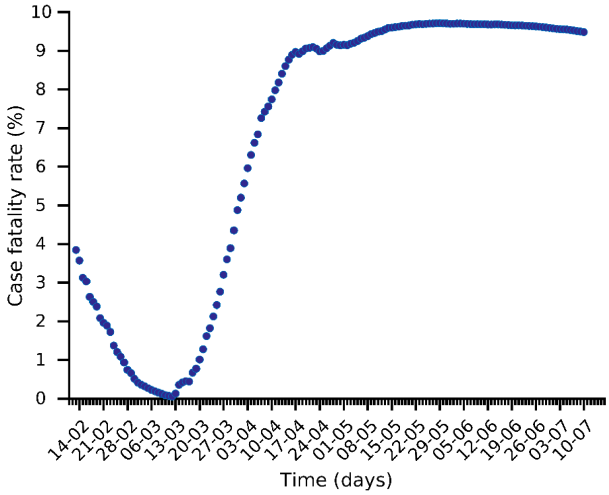


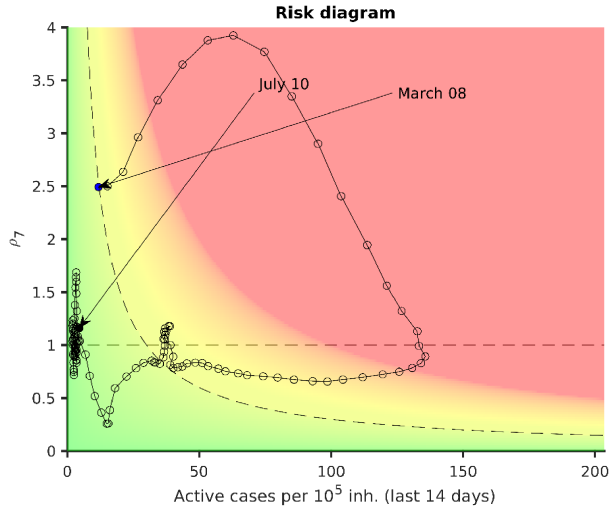


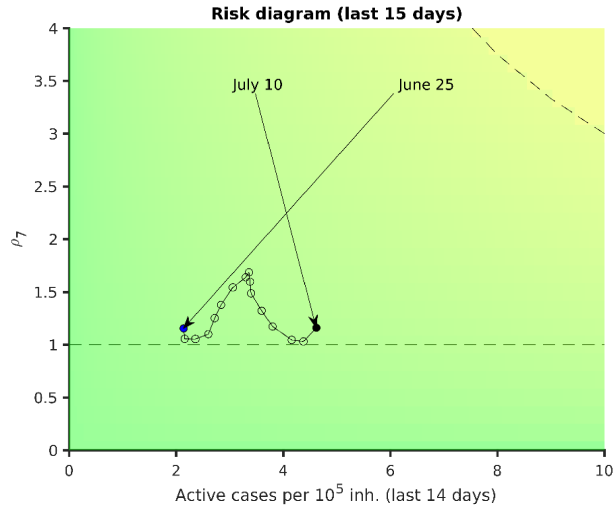




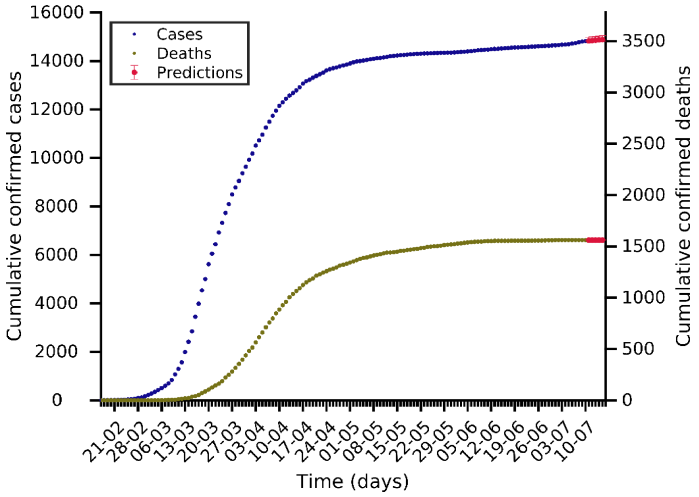


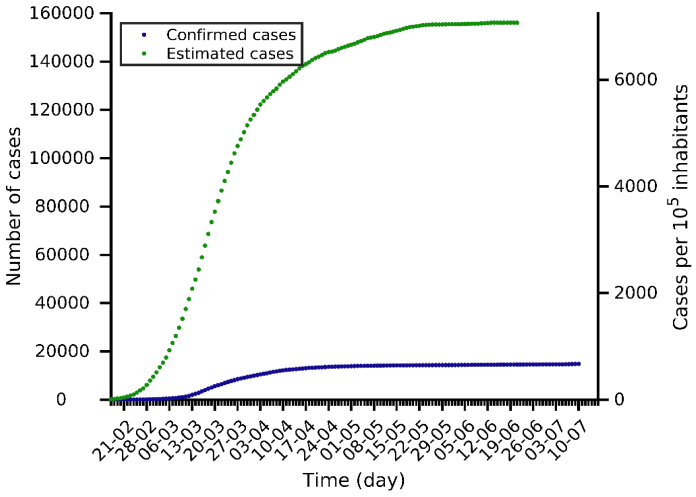


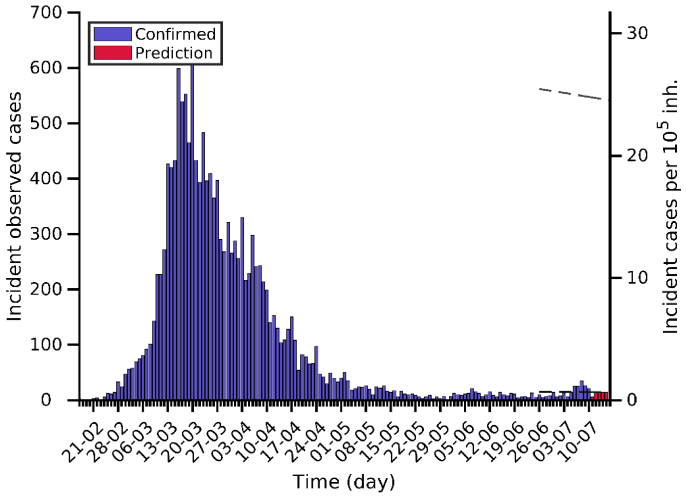


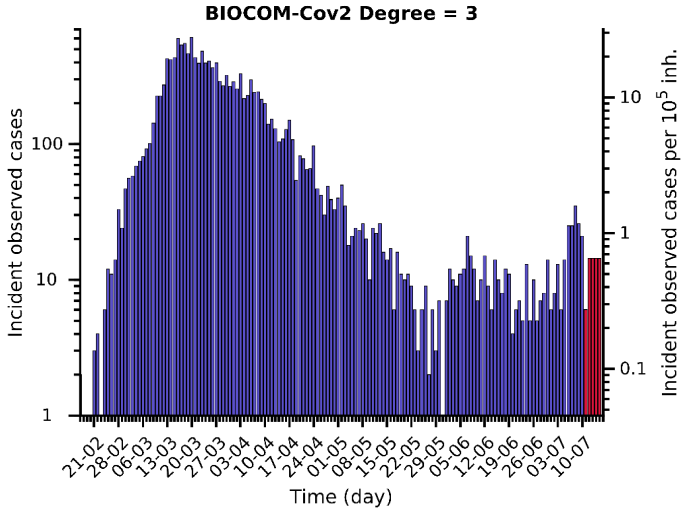


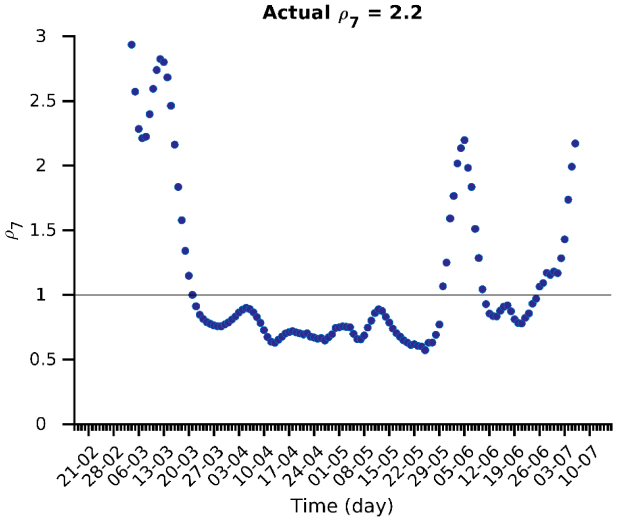
Euskadi 10-07-2020. Pop: 2.2M. Cumulative incidence: 671/10^5

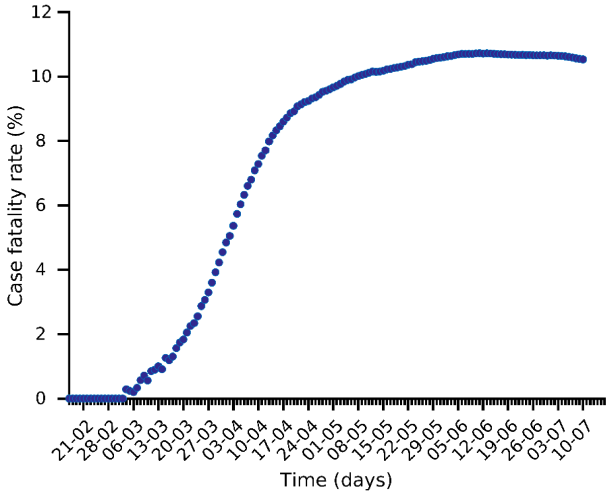


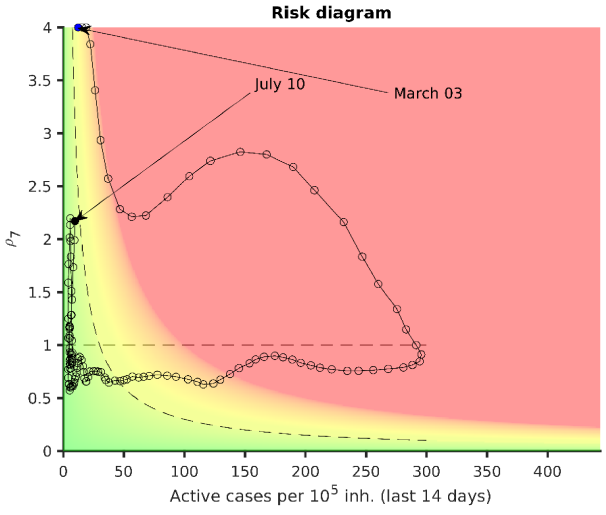


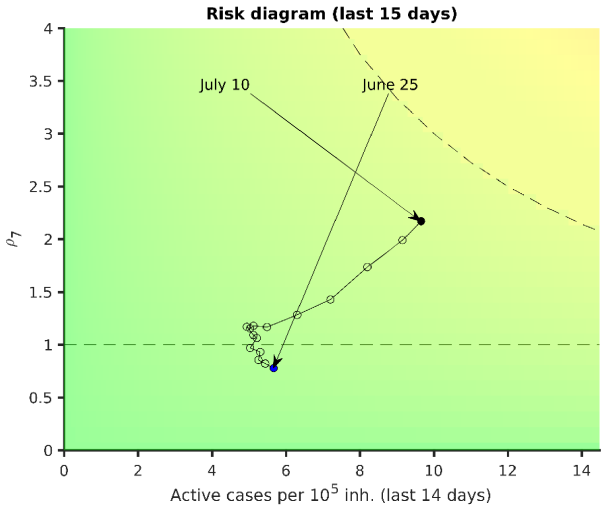




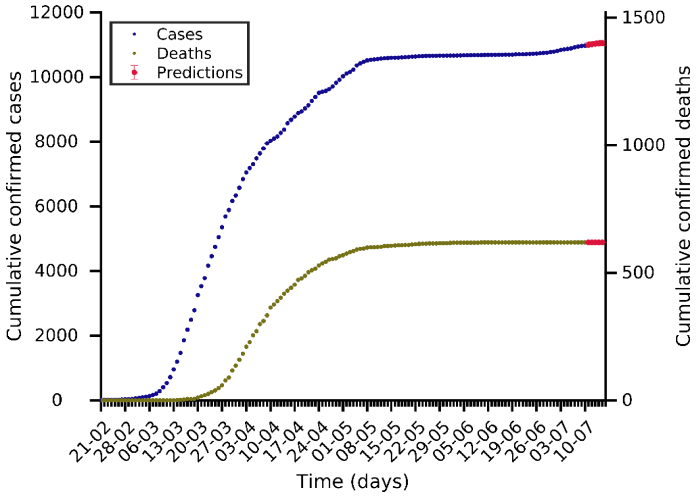


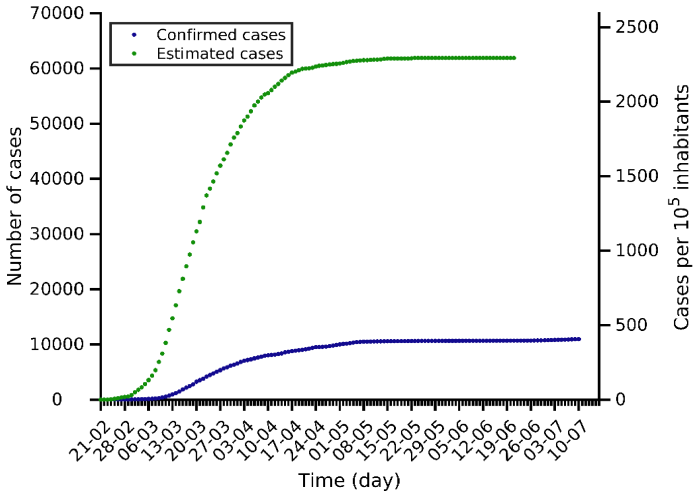


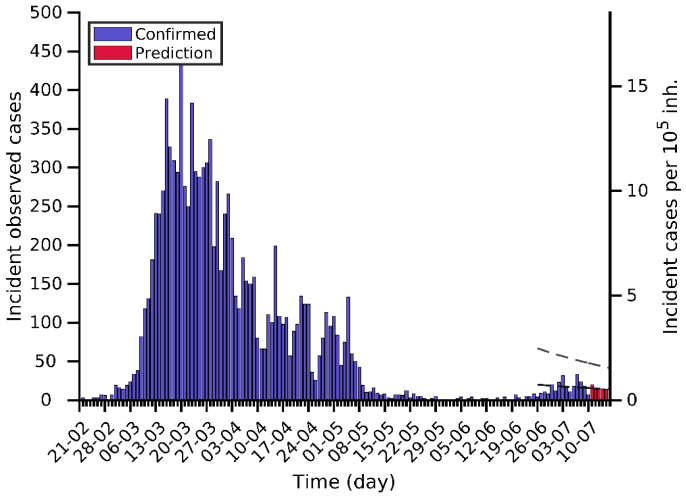


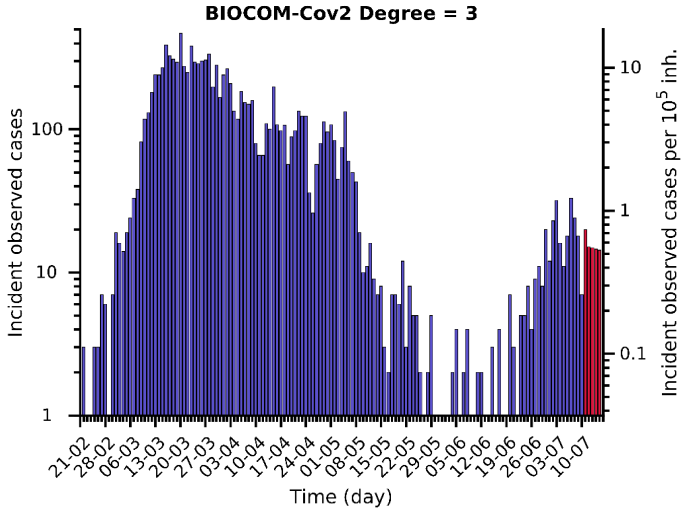


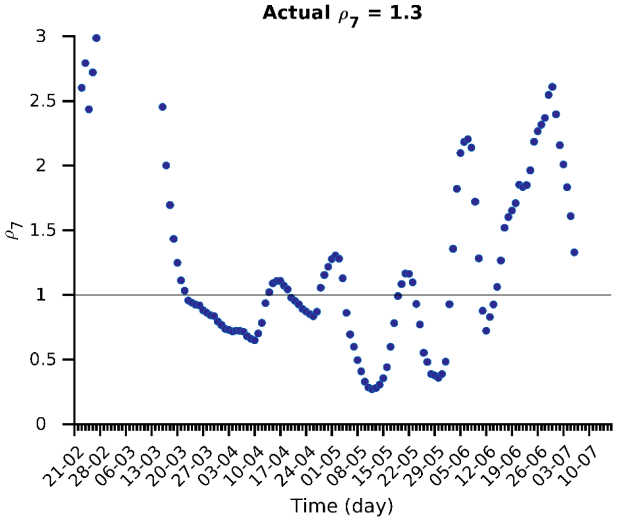
Galicia 10-07-2020. Pop: 2.7M. Cumulative incidence: 406/10⁵

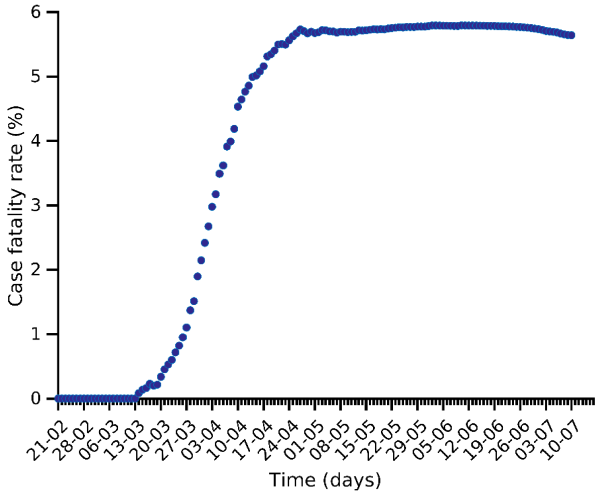


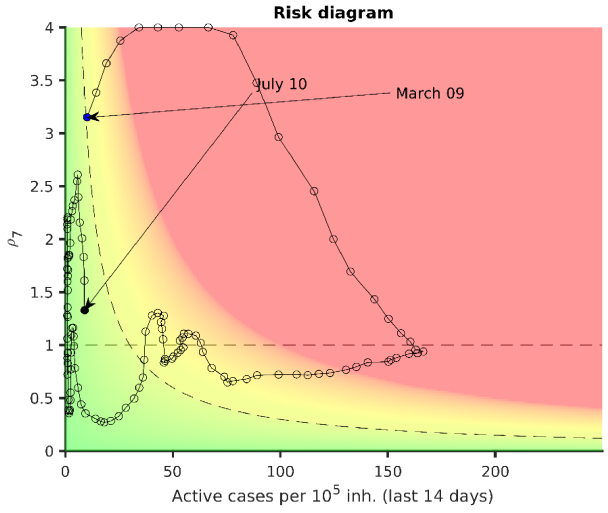


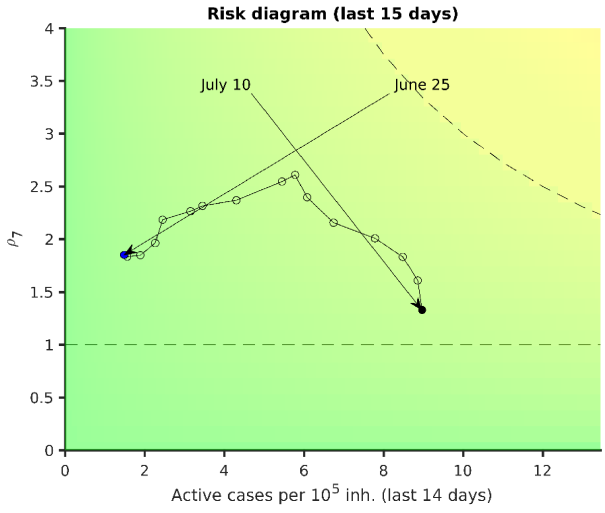




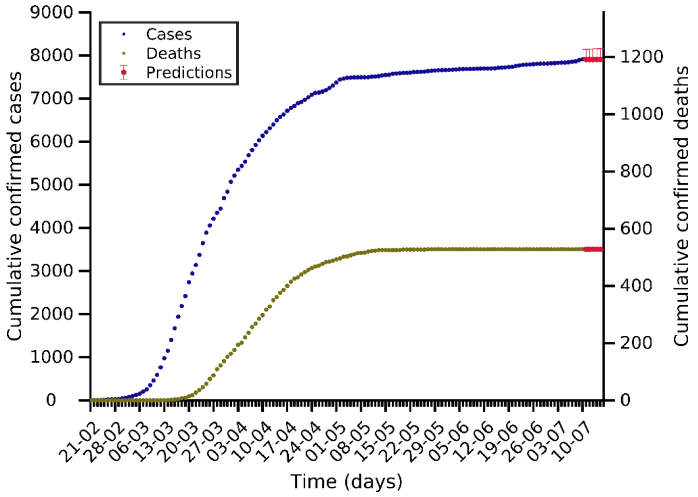


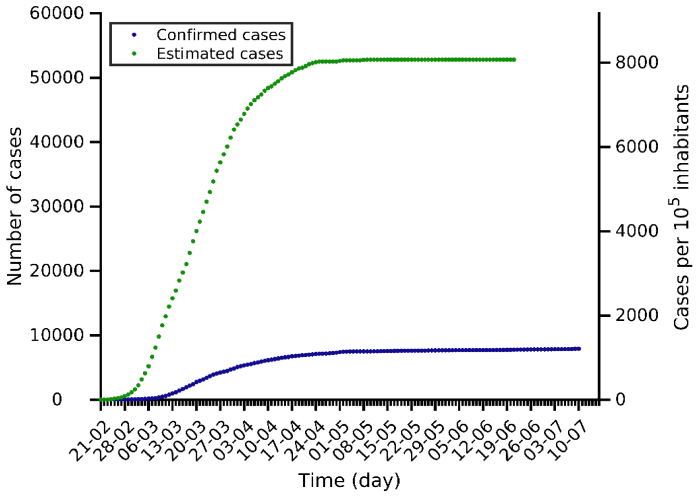


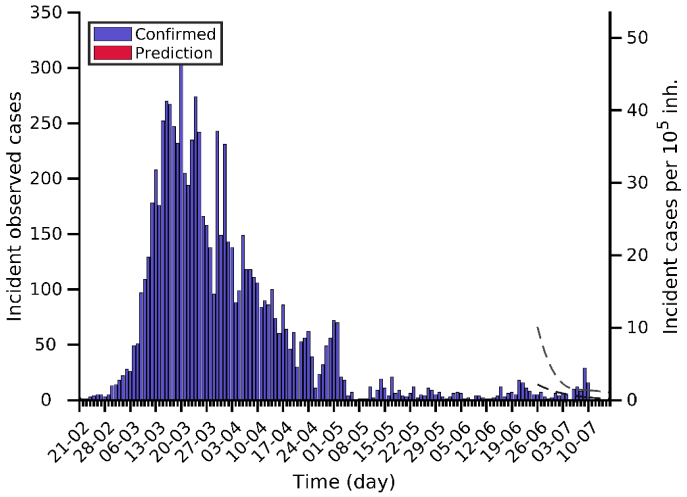


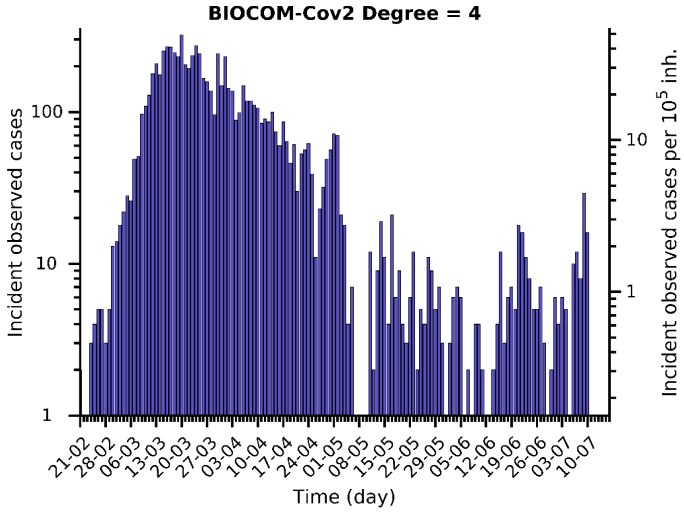


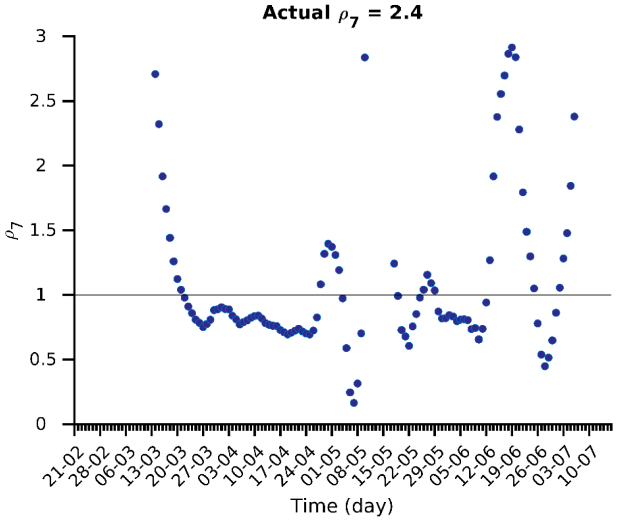
Navarra 10-07-2020. Pop: 0.7M. Cumulative incidence: 1209/10⁵

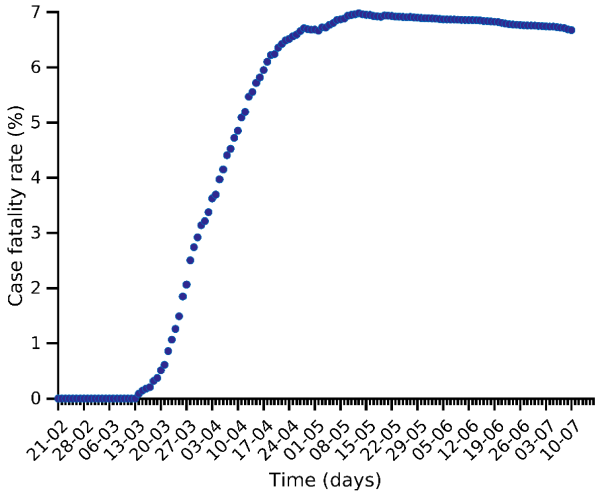


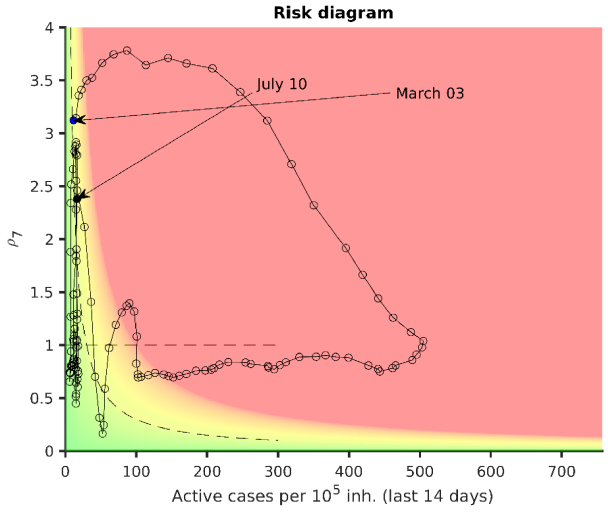


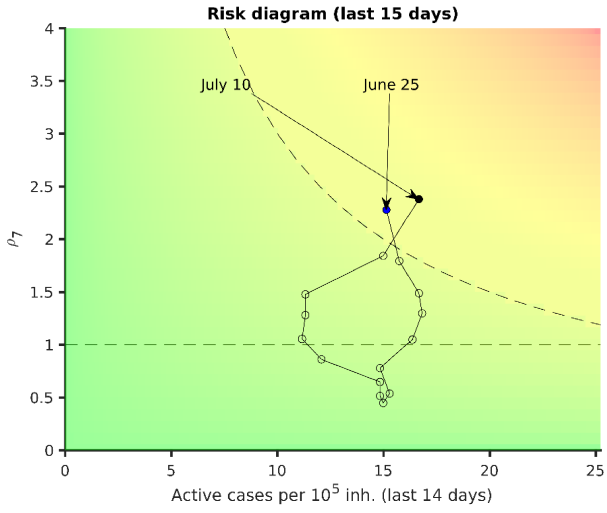




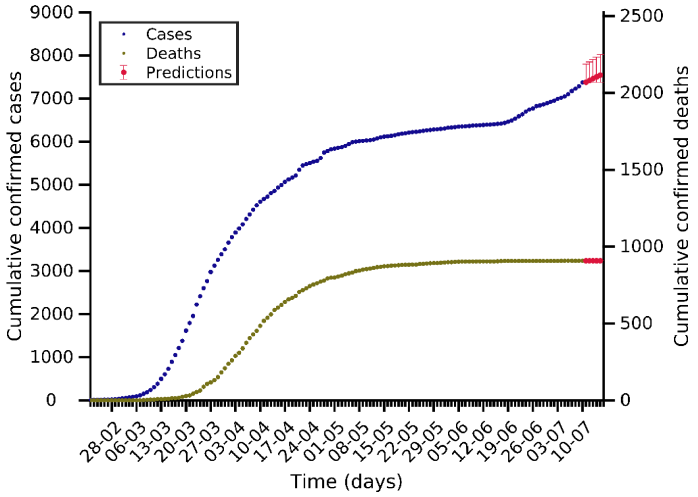


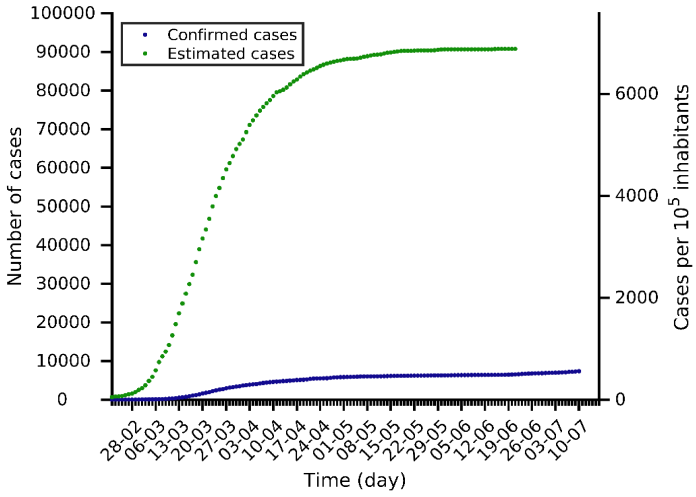


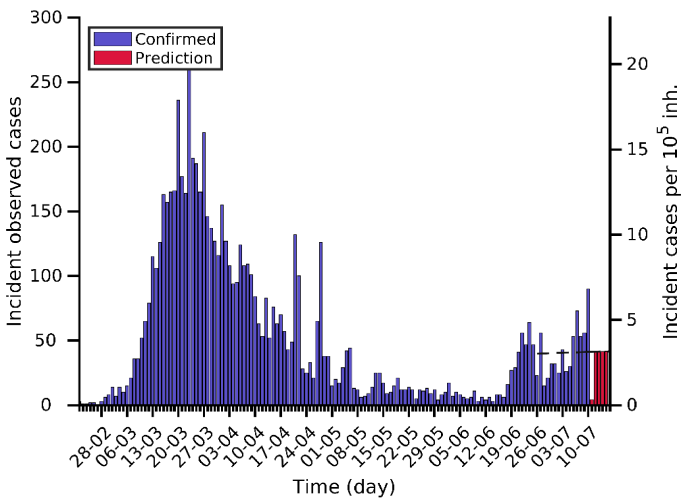


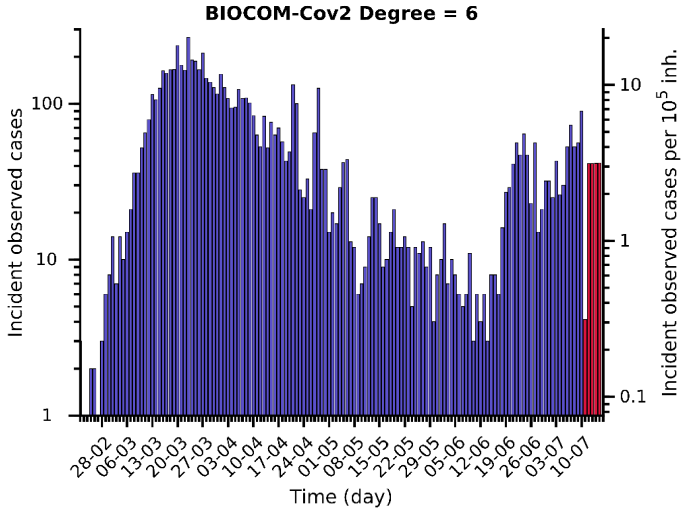


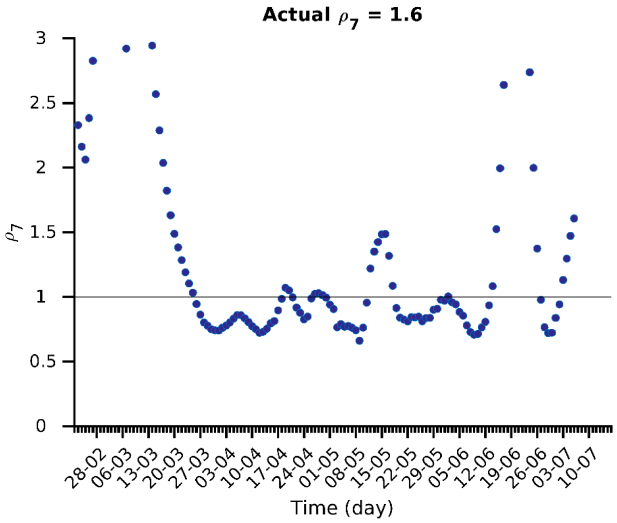
Aragon 10-07-2020. Pop: 1.3M. Cumulative incidence: 559/10⁵

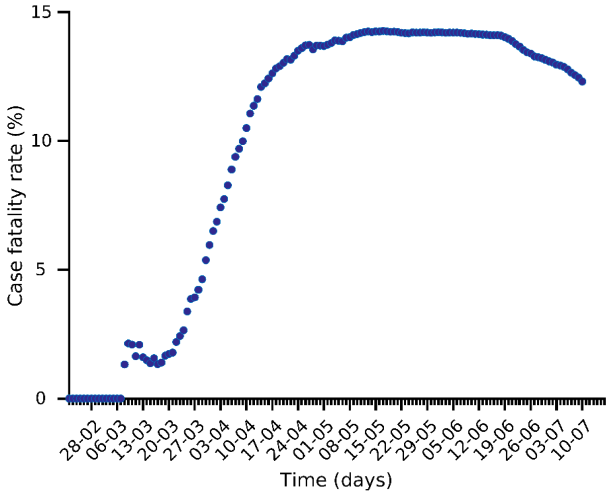


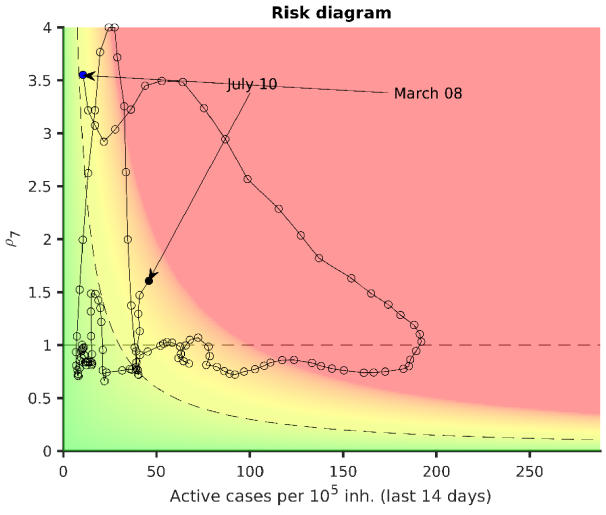


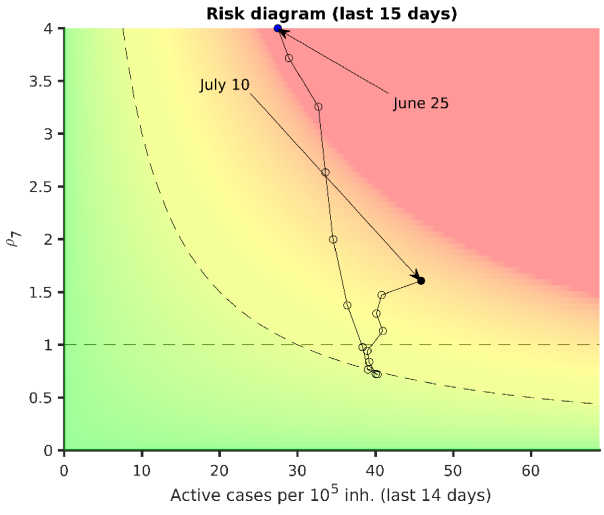




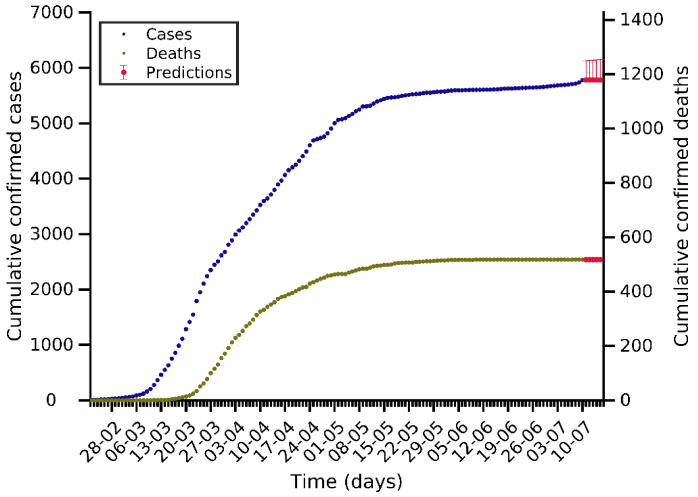


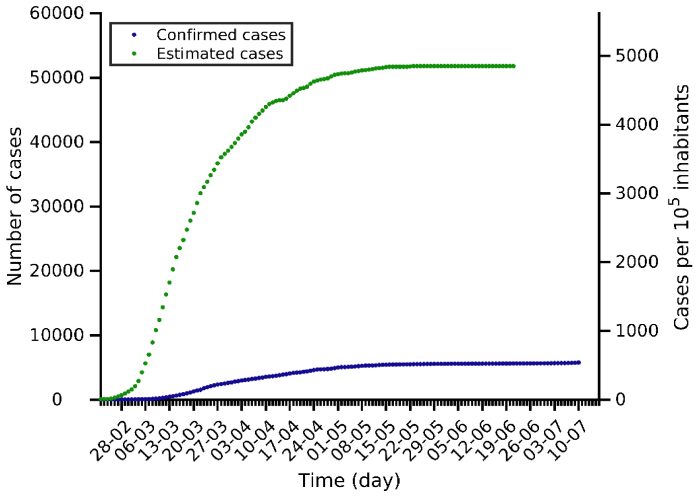


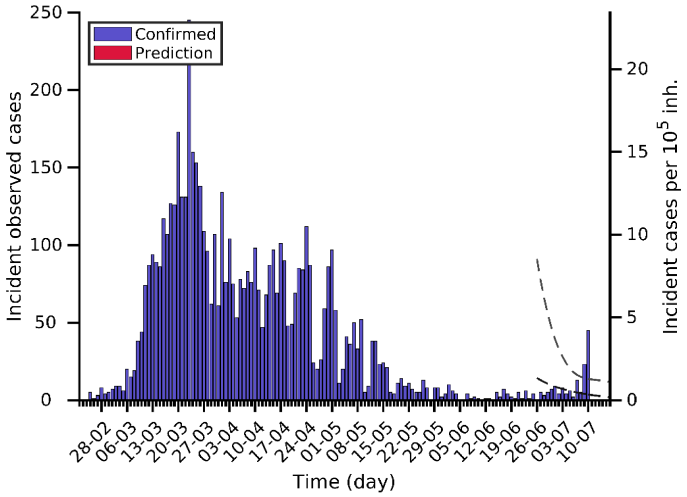


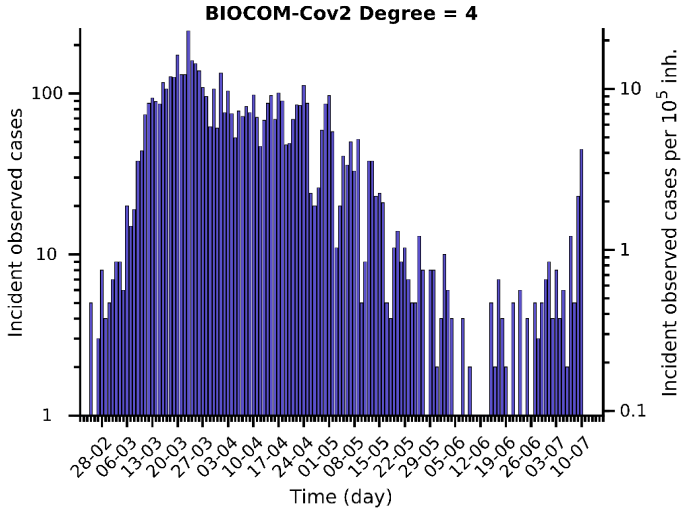


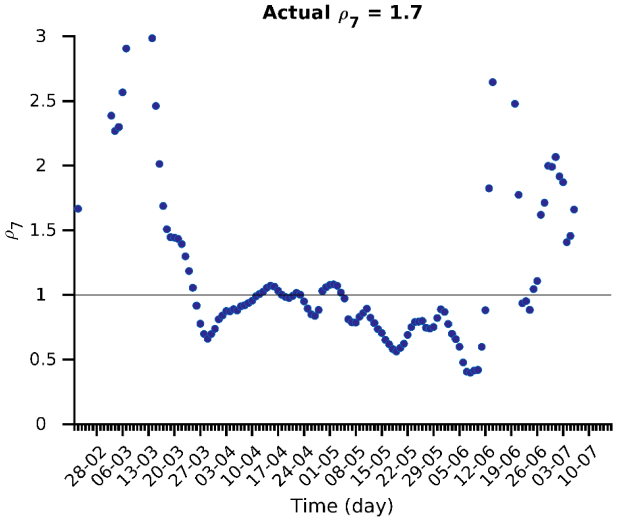
Extremadura 10-07-2020. Pop: 1.1M. Cumulative incidence: 542/10⁵

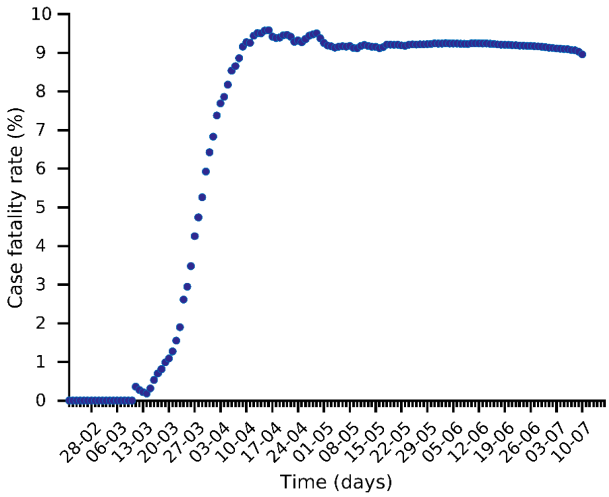


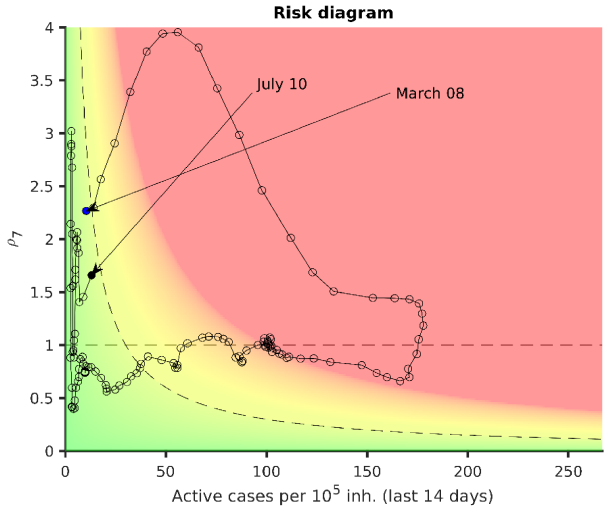


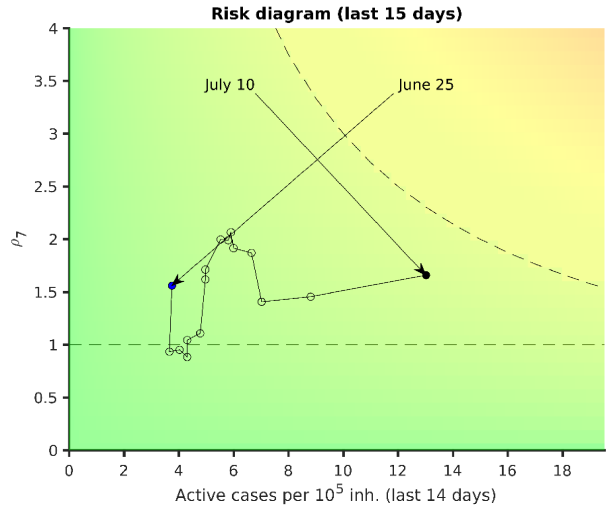




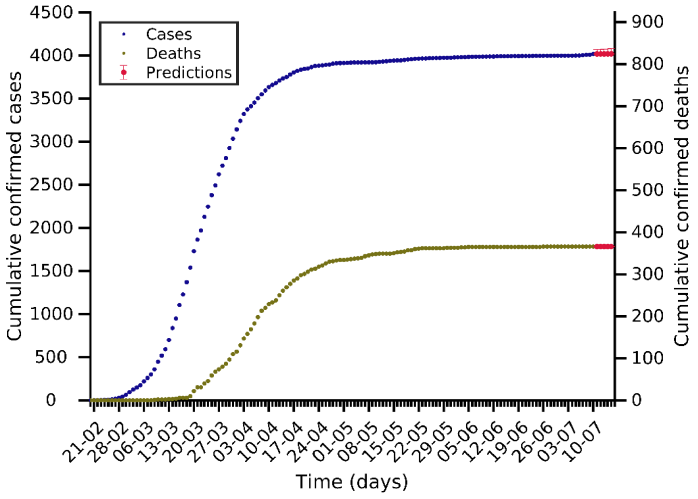


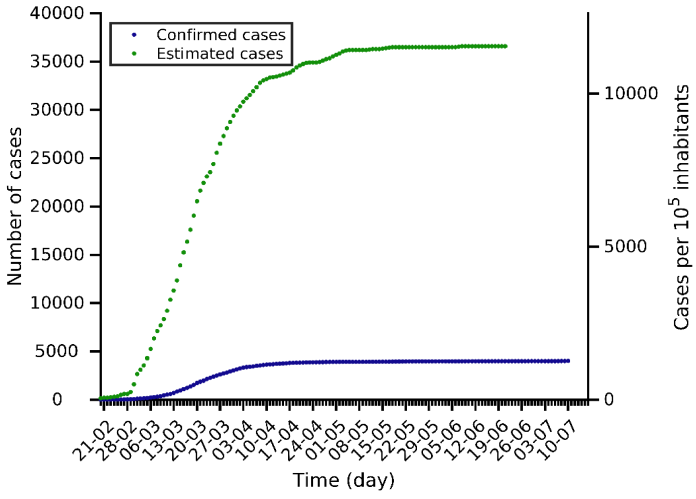


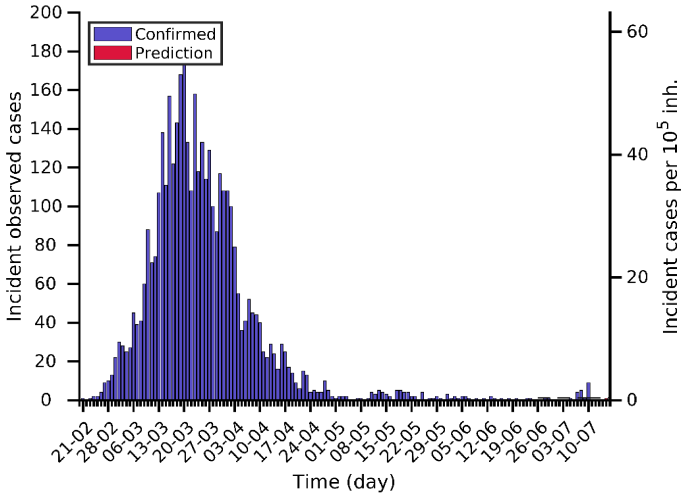


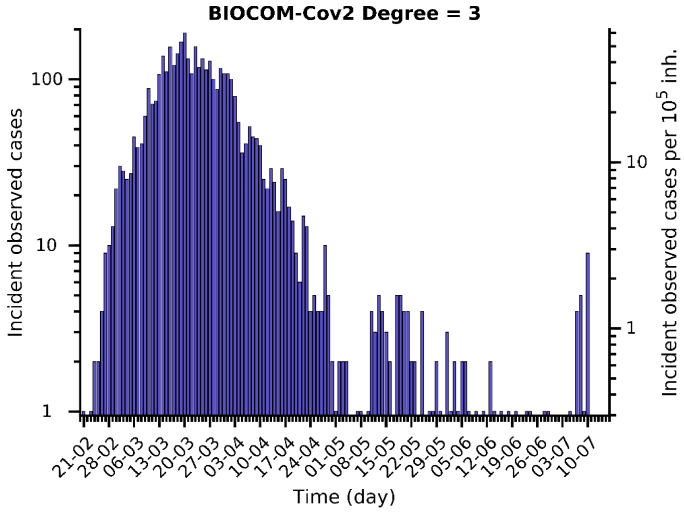


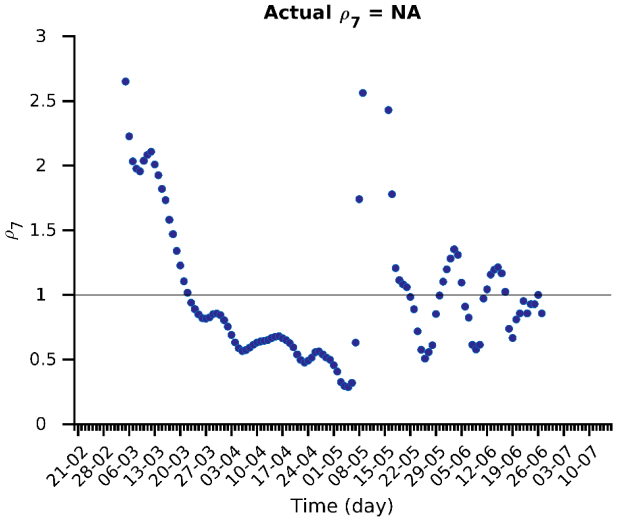
La Rioja 10-07-2020. Pop: 0.3M. Cumulative incidence: 1269/10⁵

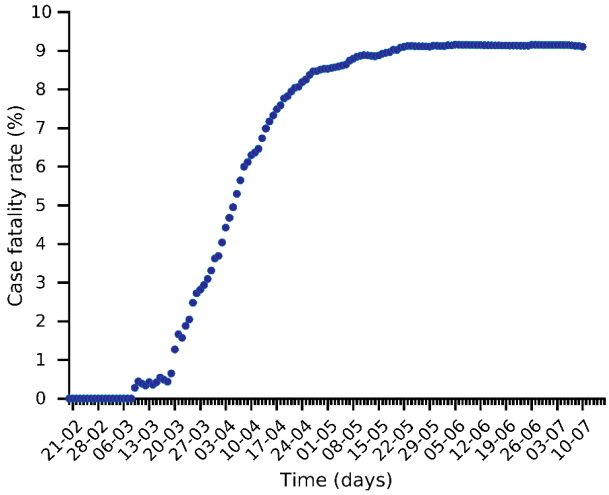


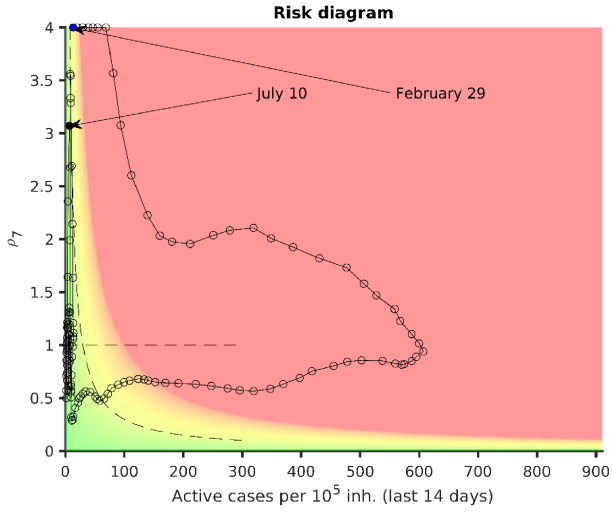


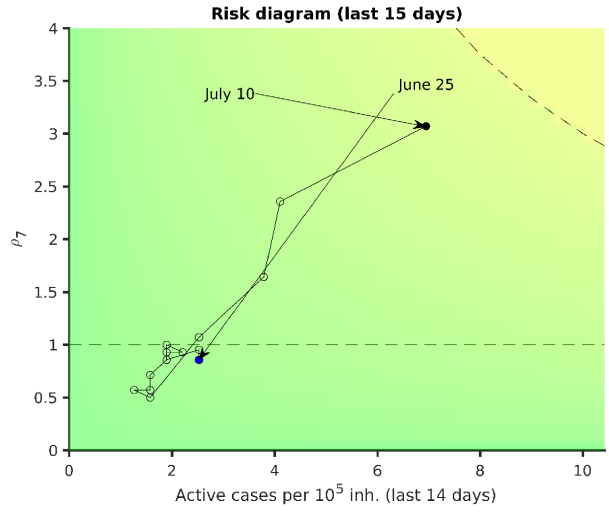




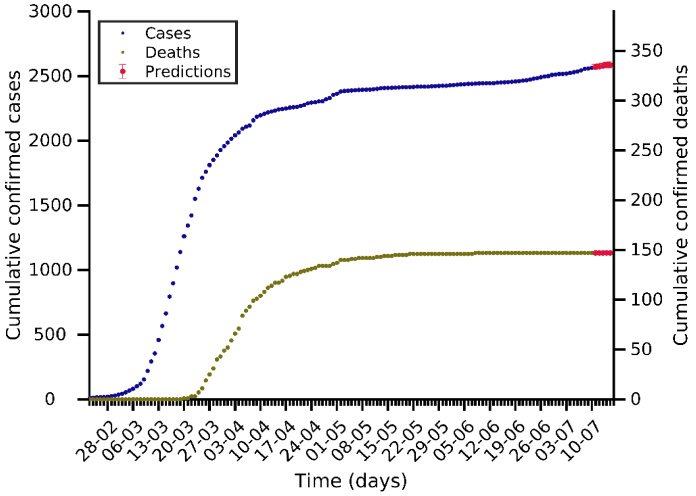


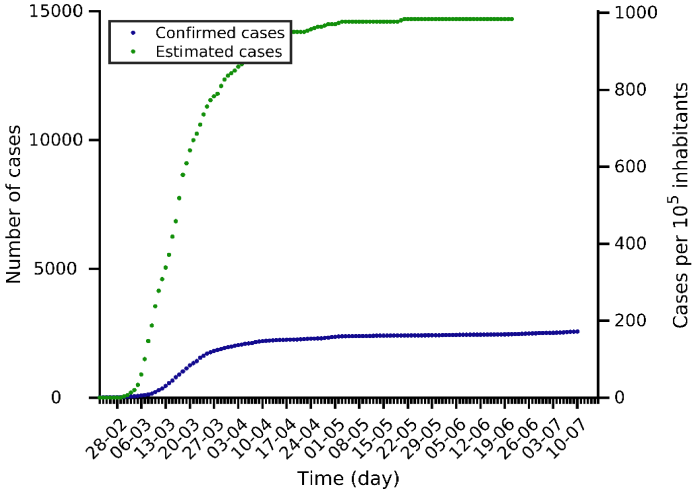


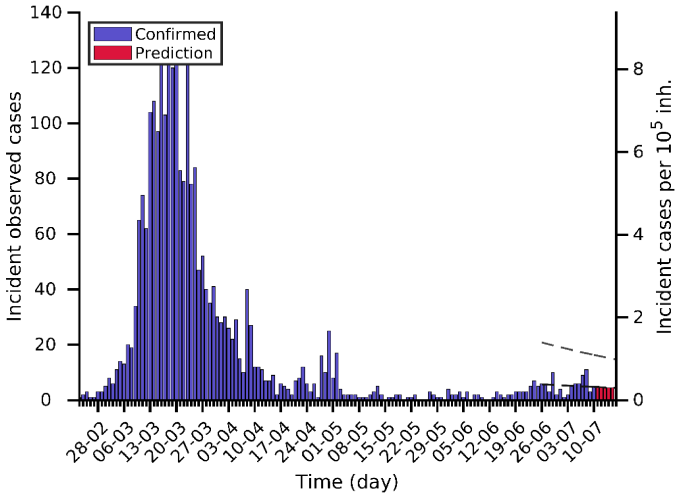


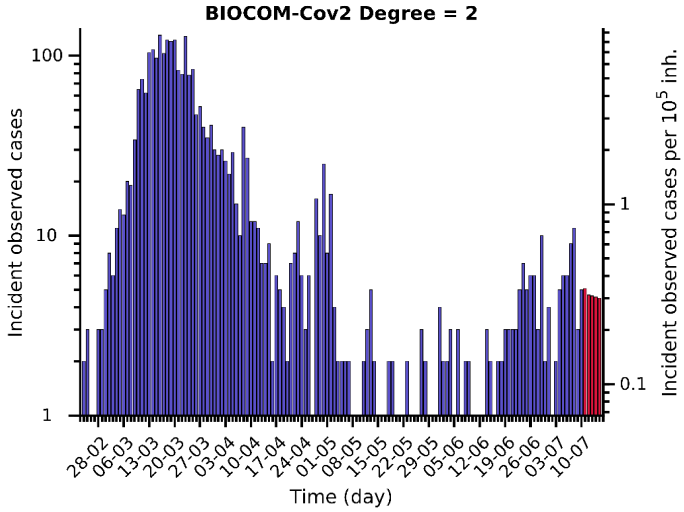


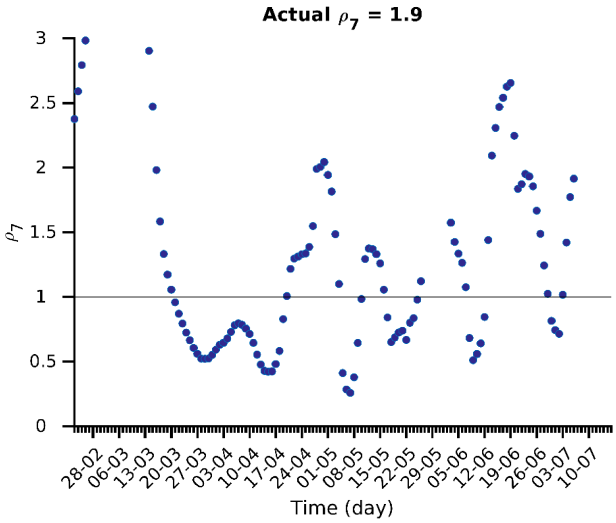
Murcia 10-07-2020. Pop: 1.5M. Cumulative incidence: 172/10⁵

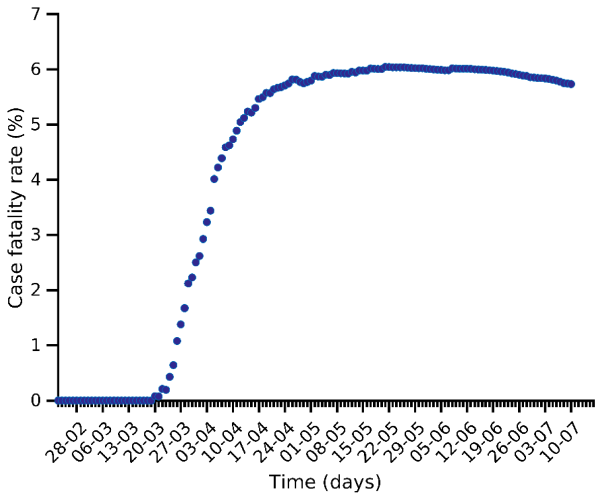


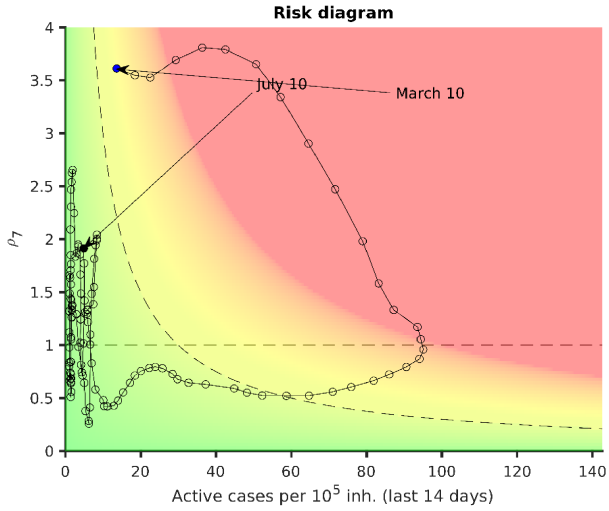


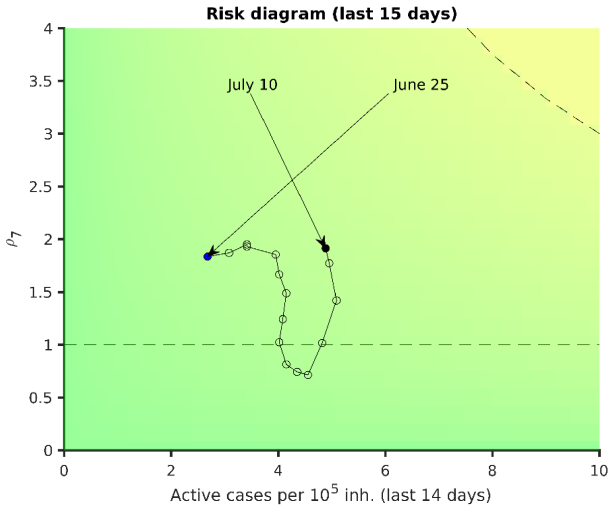




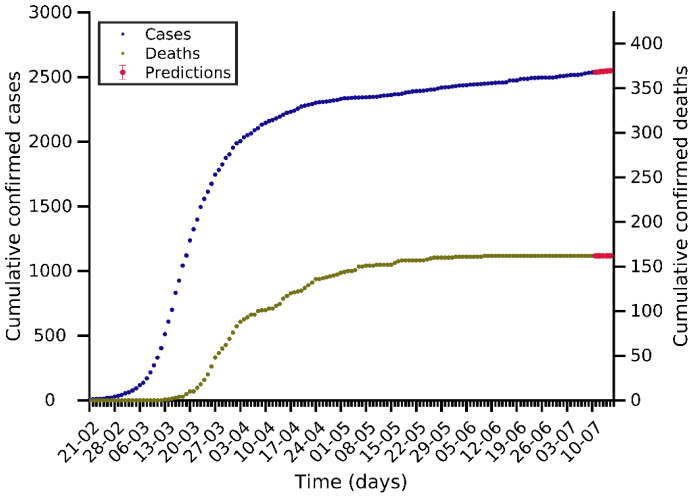


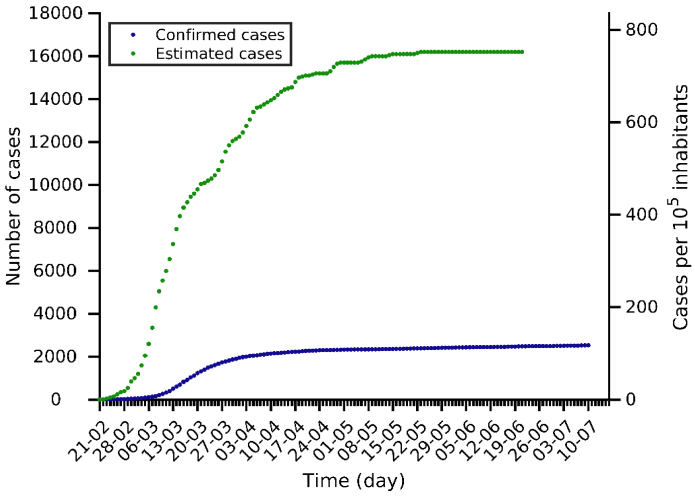


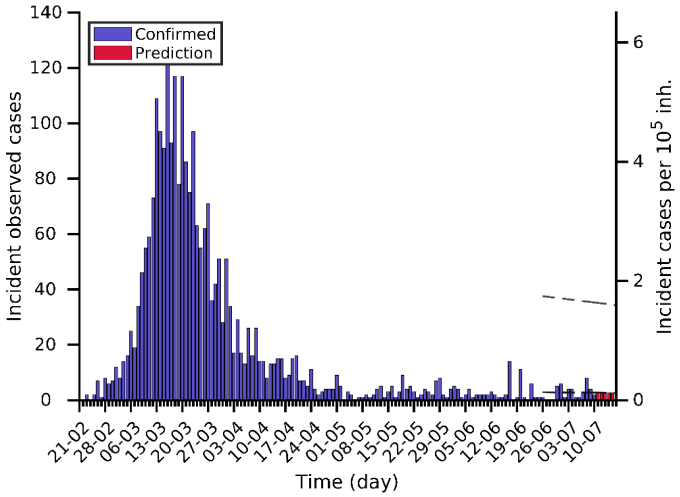


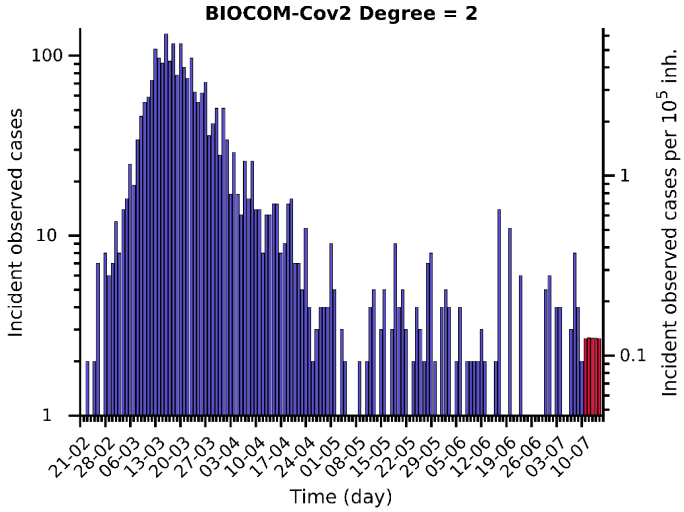


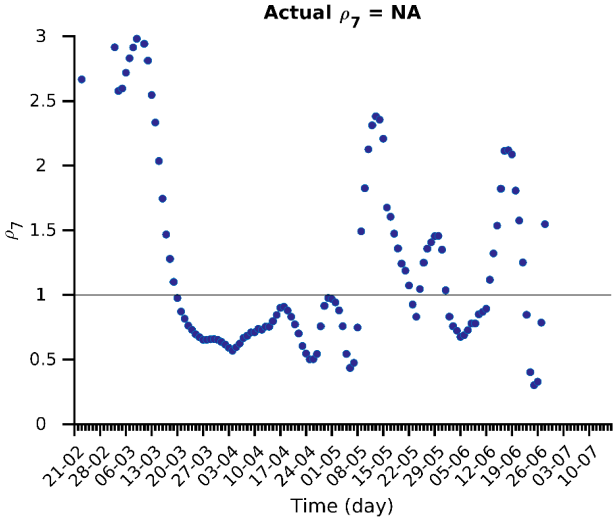
Canarias 10-07-2020. Pop: 2.2M. Cumulative incidence: 118/10⁵

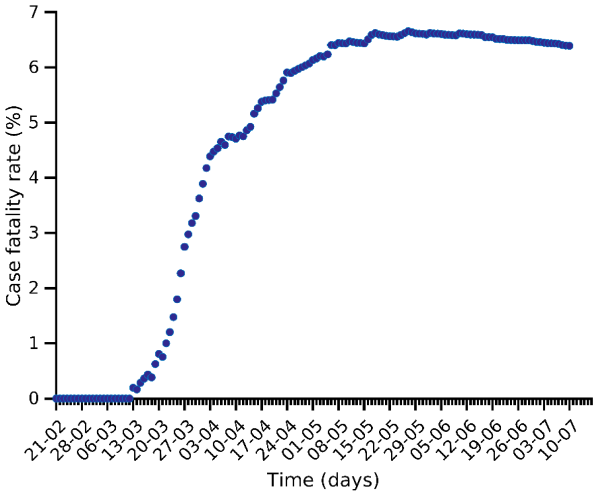


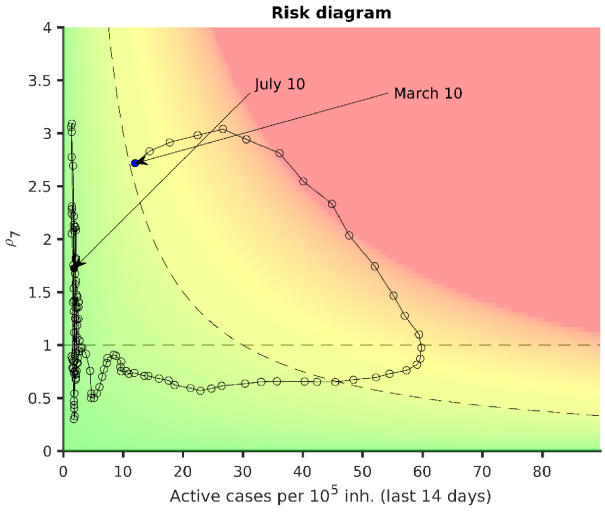


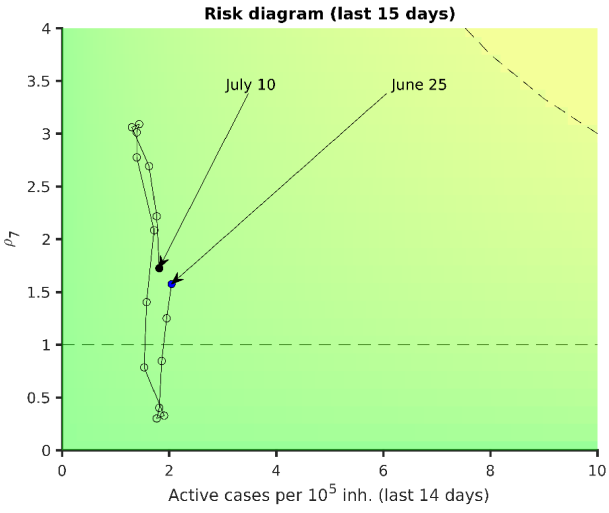




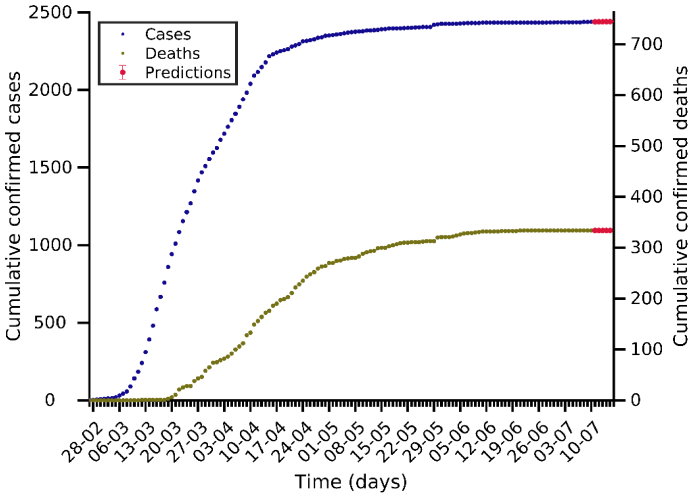


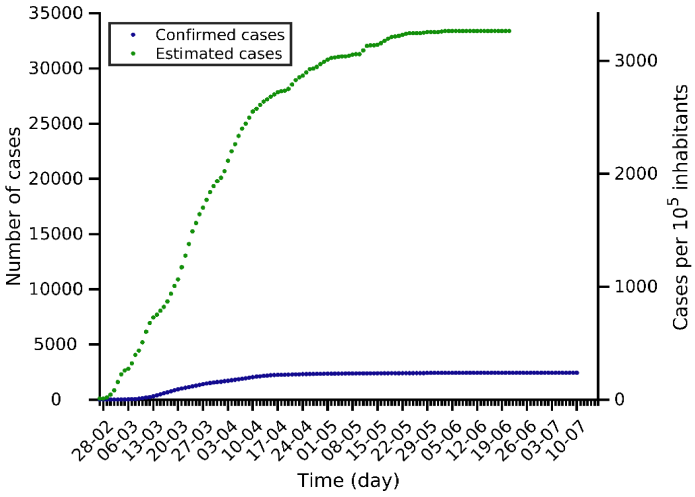


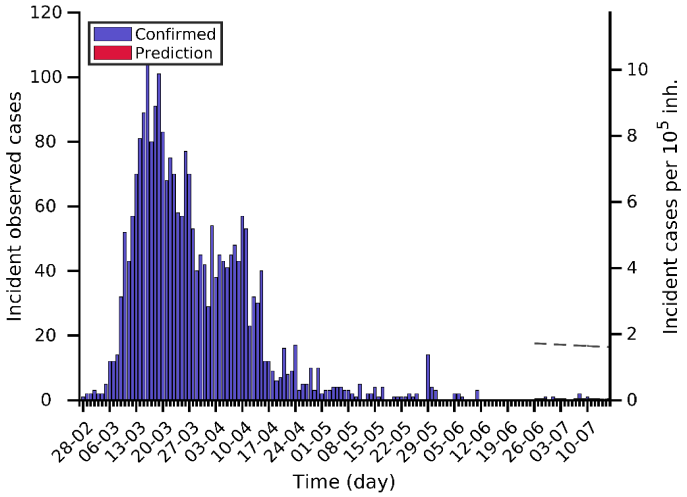


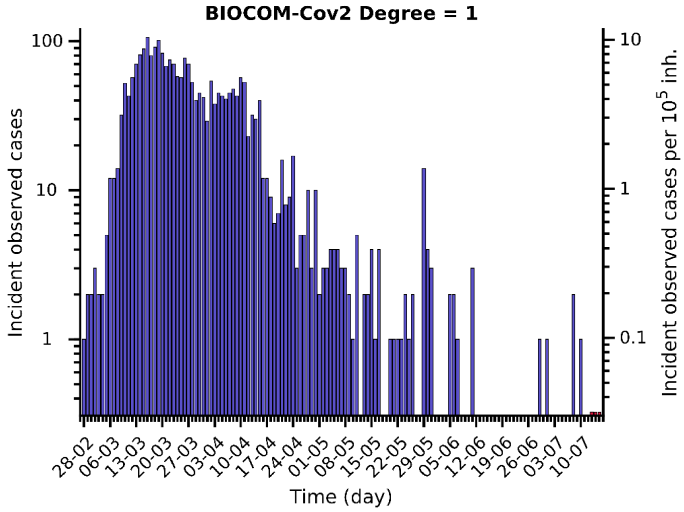


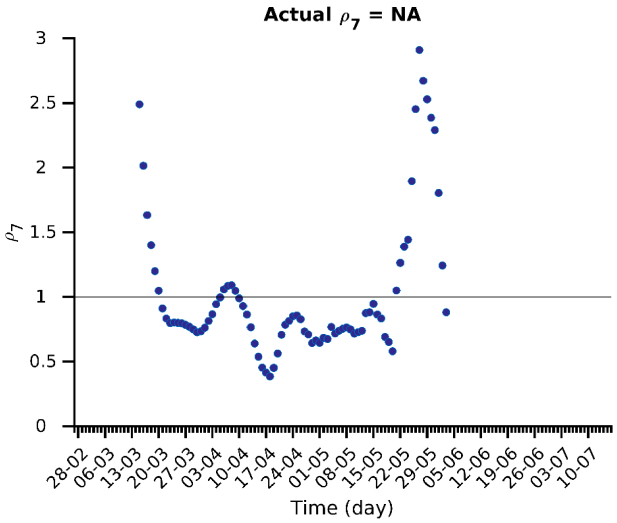
Asturias 10-07-2020. Pop: 1.0M. Cumulative incidence: 239/10⁵

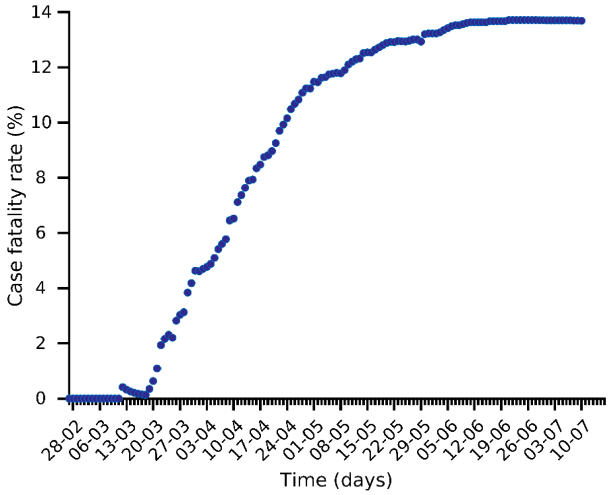


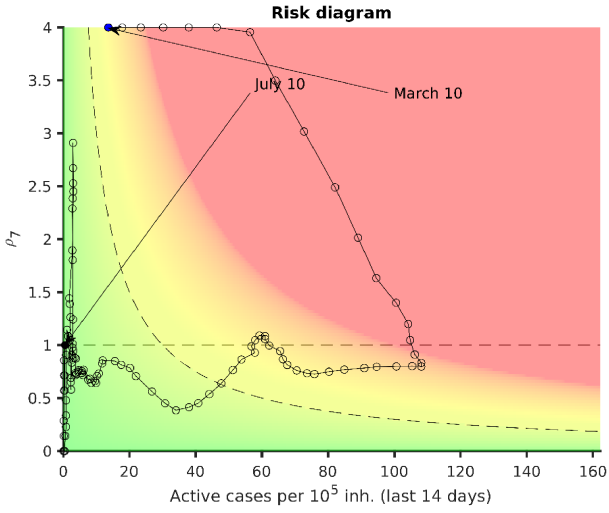


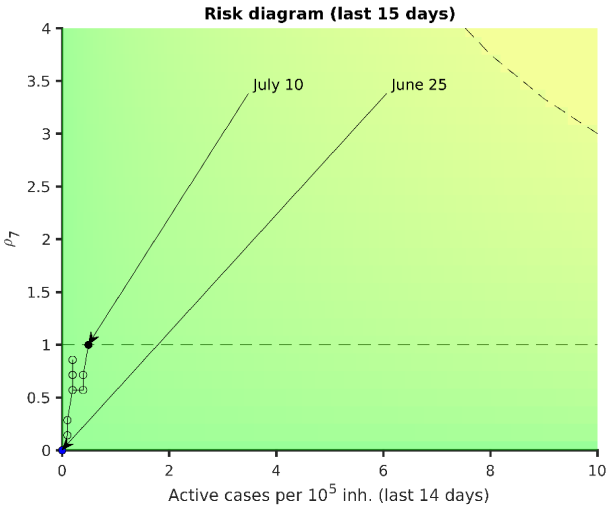




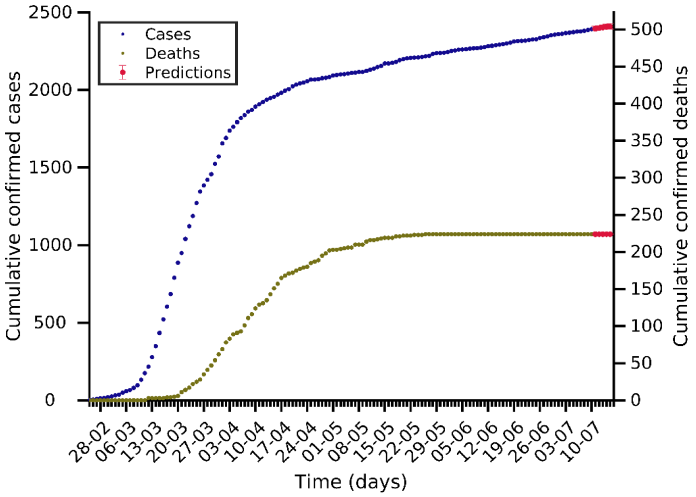


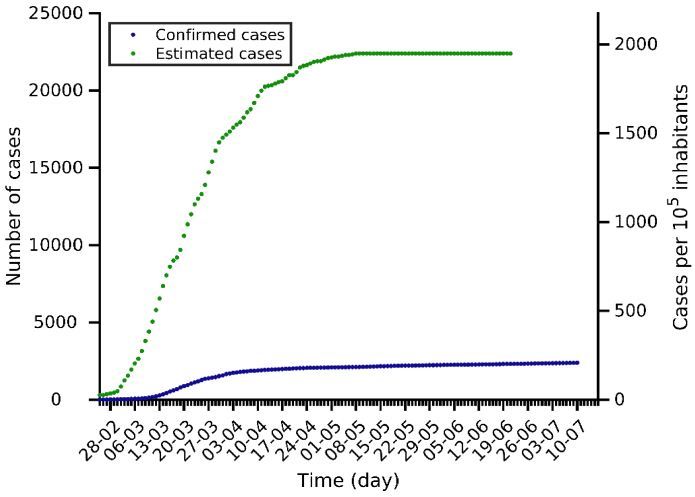


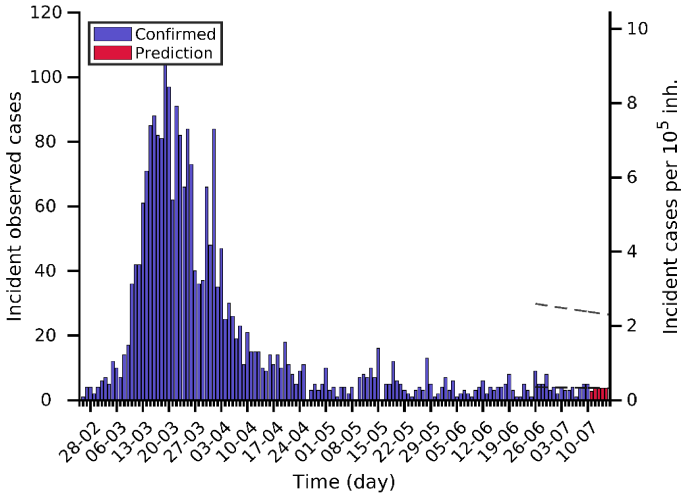


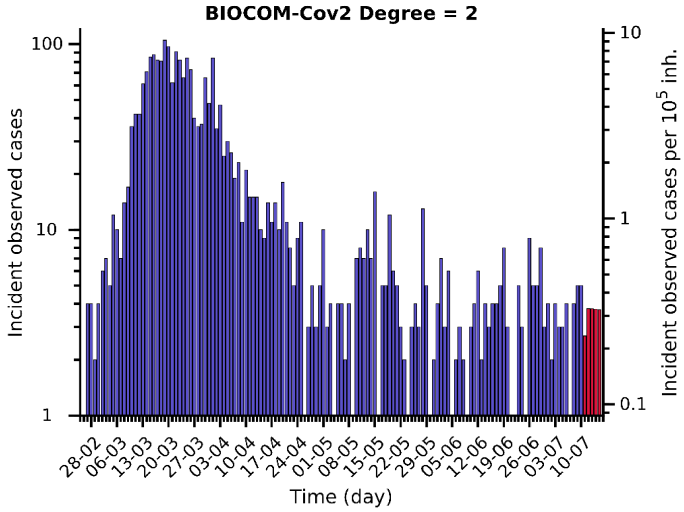


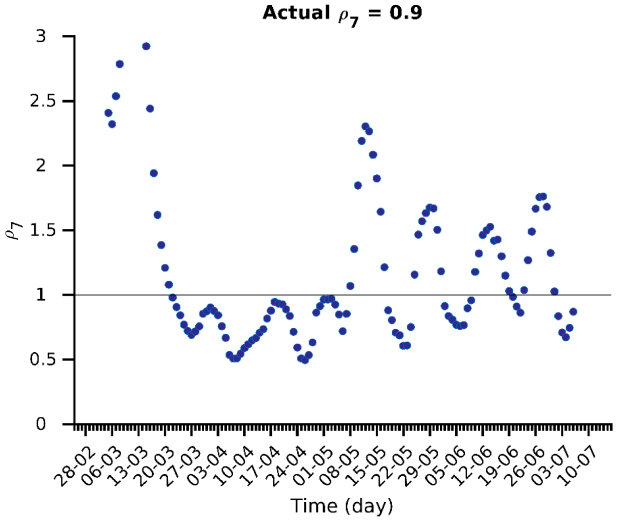
Baleares 10-07-2020. Pop: 1.1M. Cumulative incidence: 208/10^5

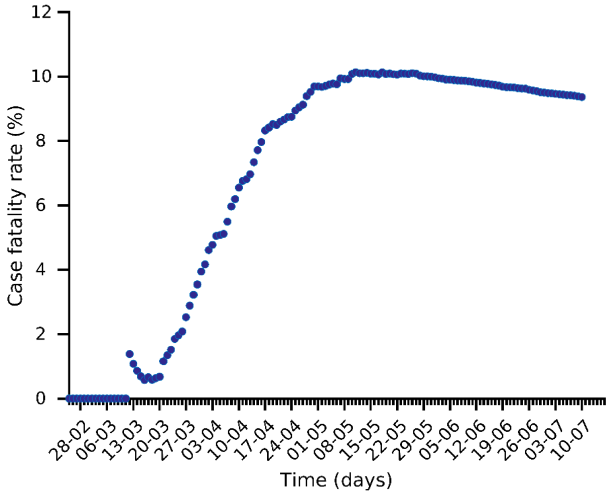


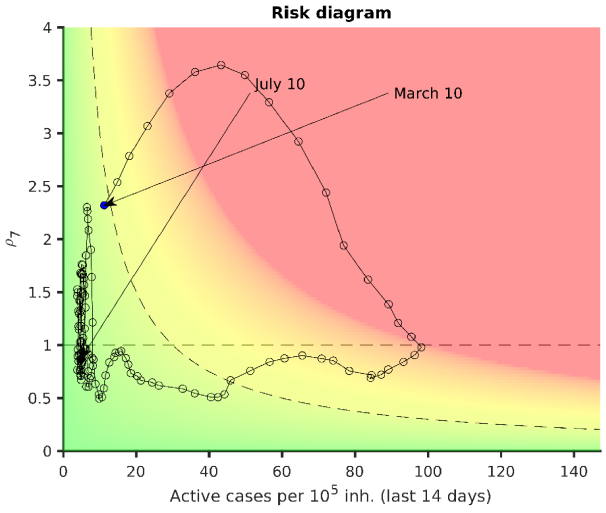


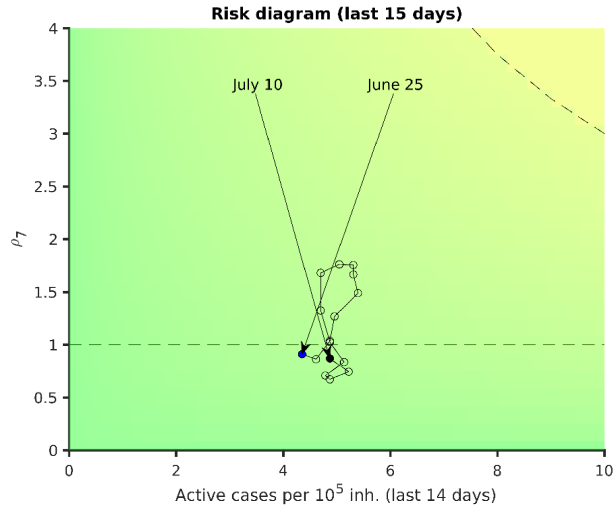




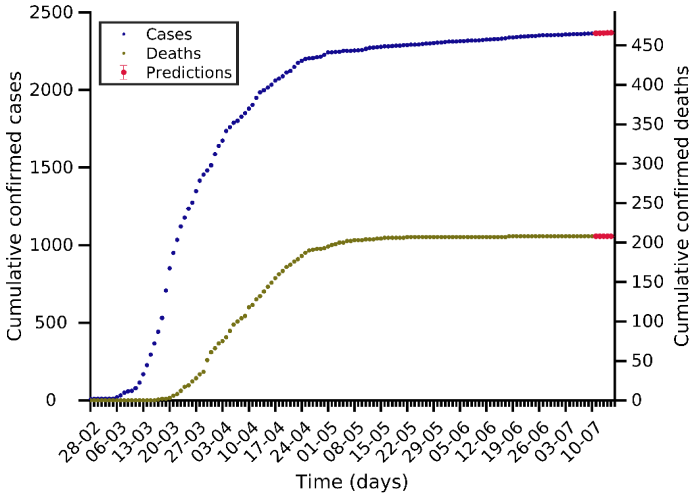


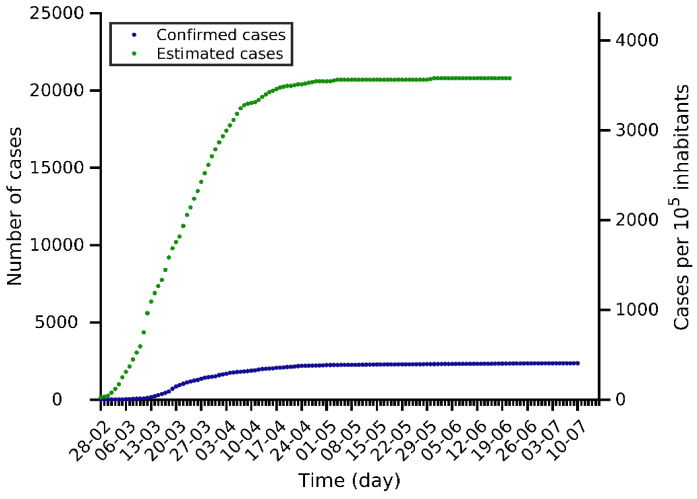


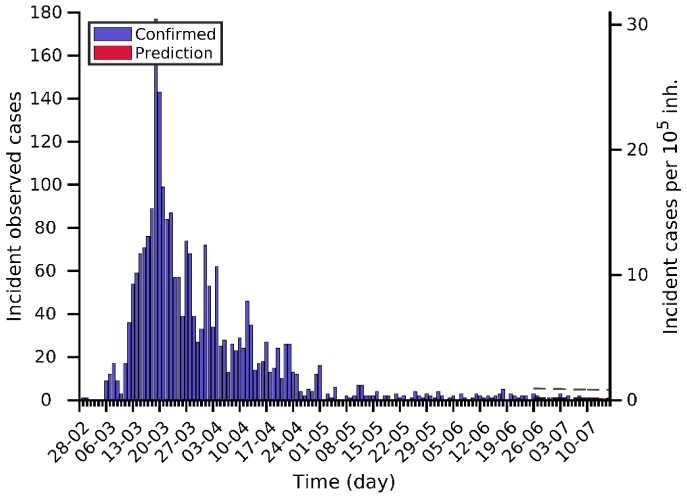


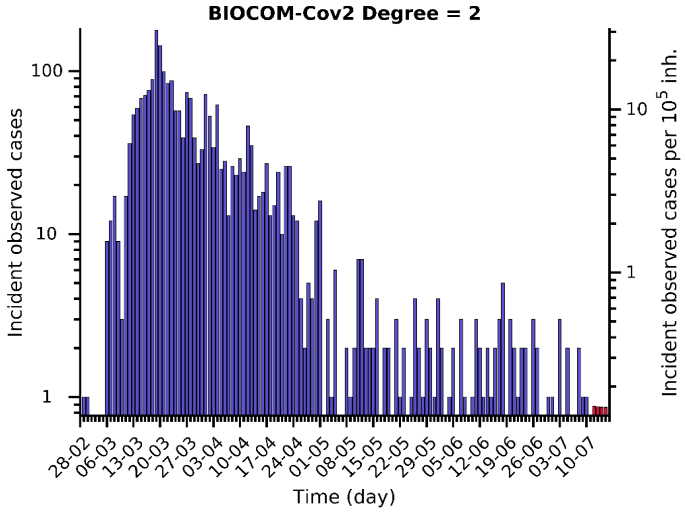


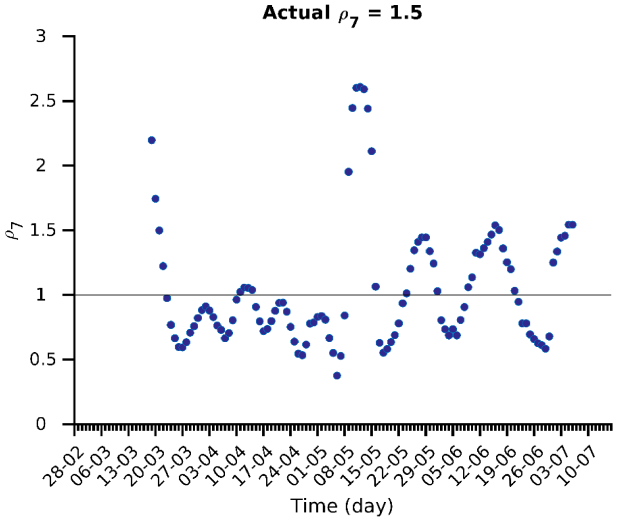
Cantabria 10-07-2020. Pop: 0.6M. Cumulative incidence: 407/10⁵

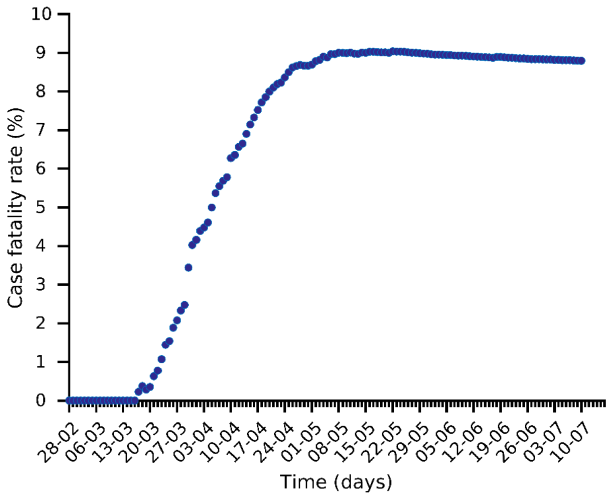


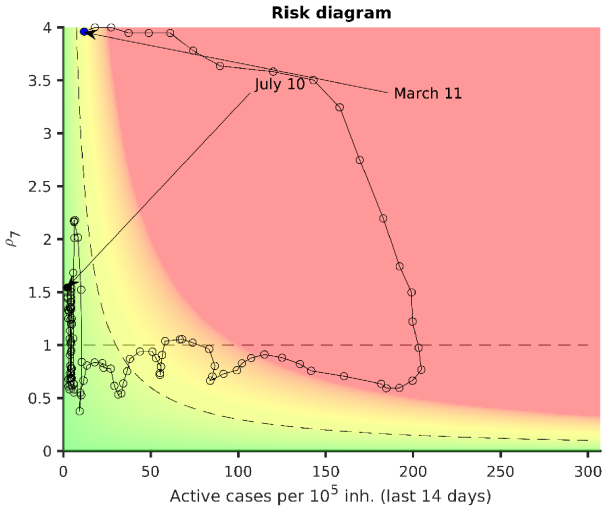


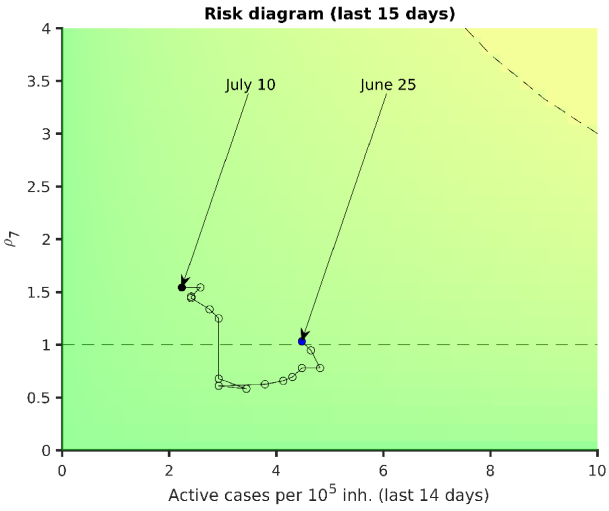




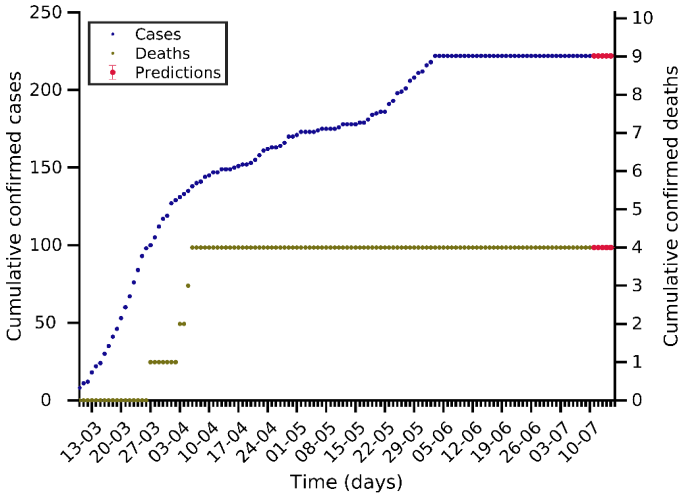


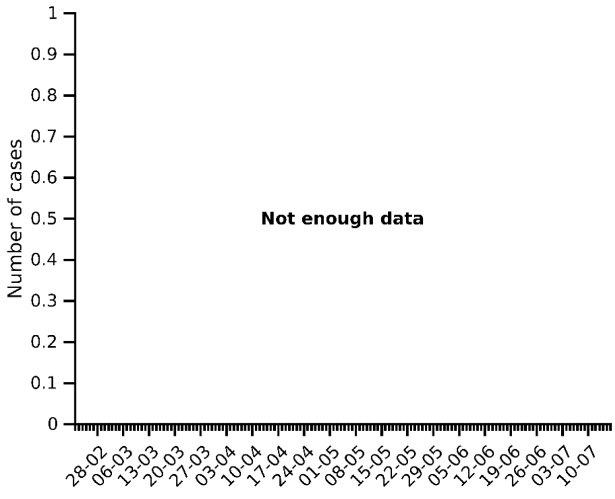


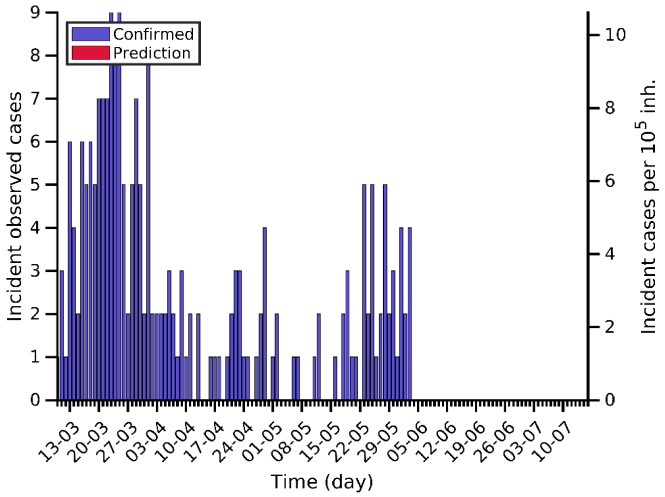


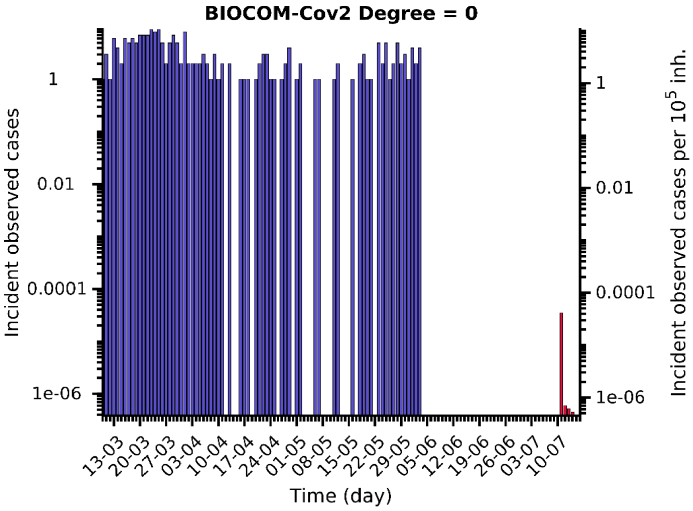


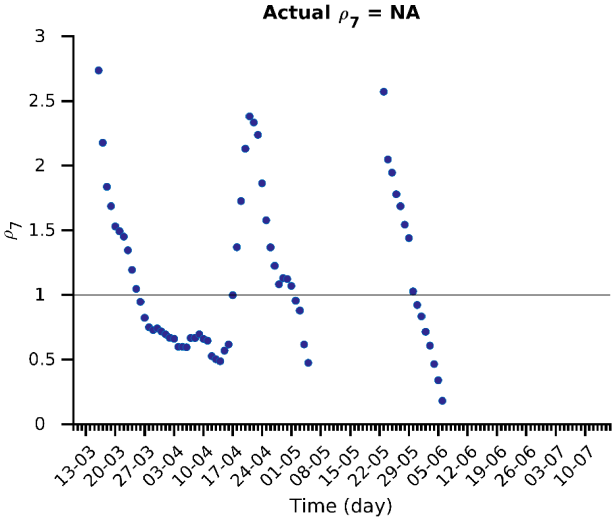
Ceuta 10-07-2020. Pop: 0.1M. Cumulative incidence: 262/10⁵

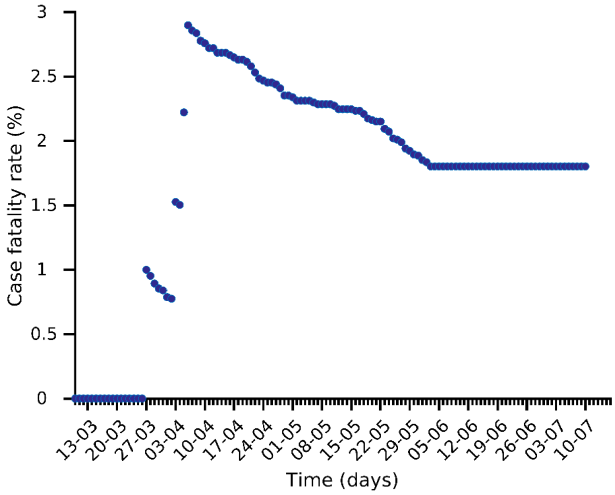


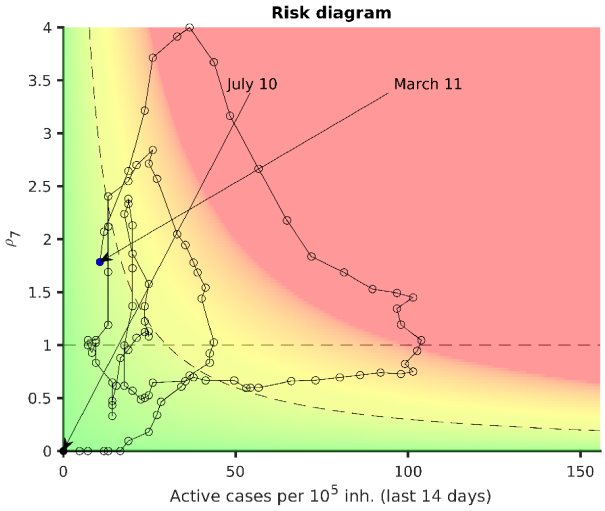


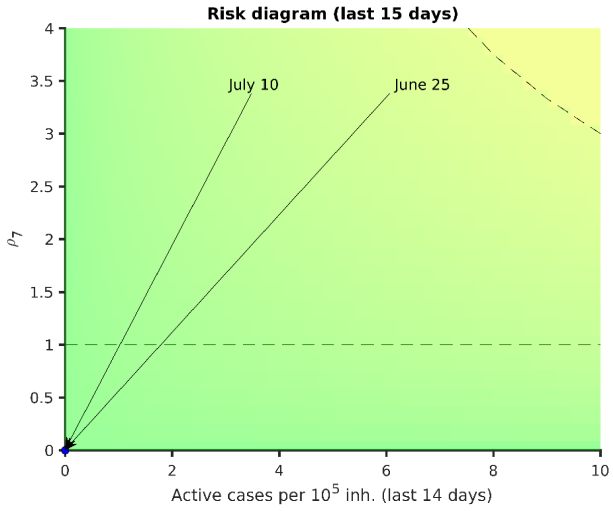








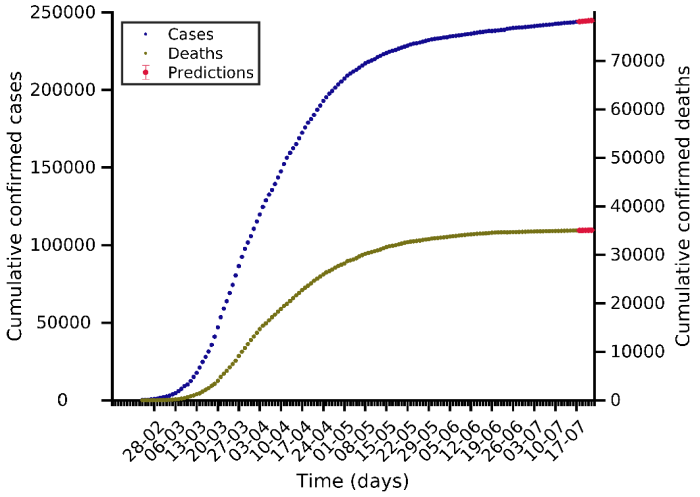


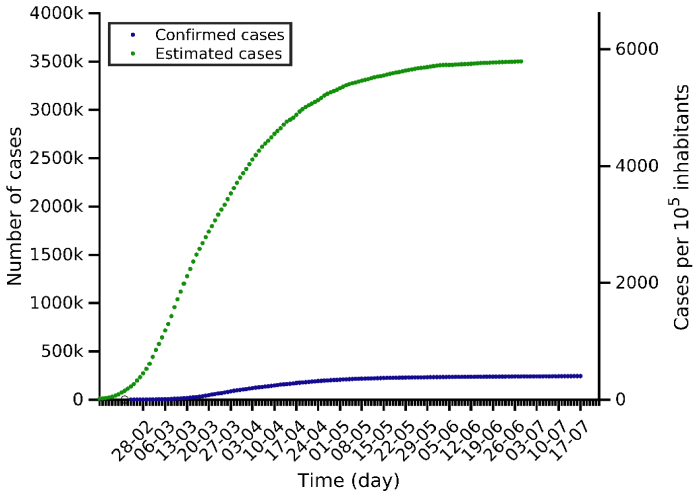


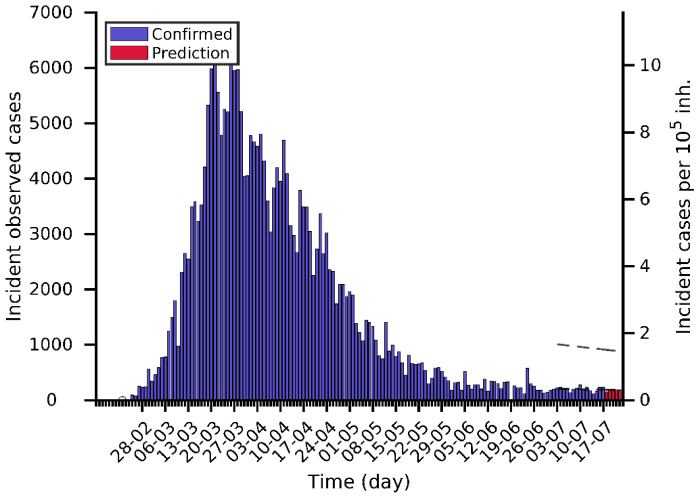
(3) Analysis and prediction of COVID-19 for Italy and its regions

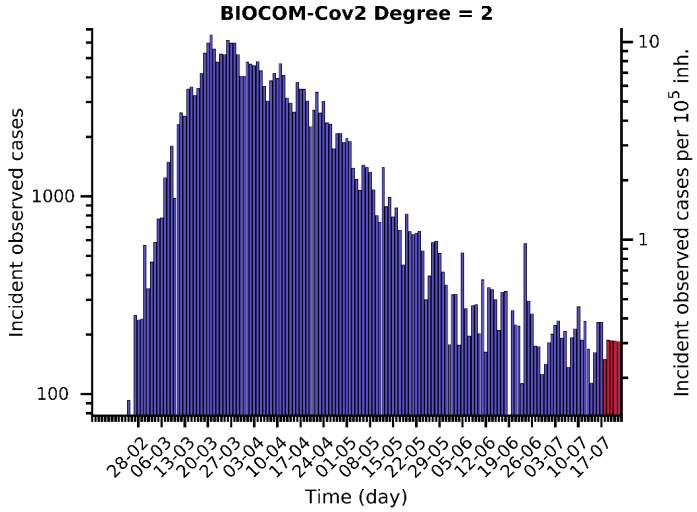
Data obtained from: https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale

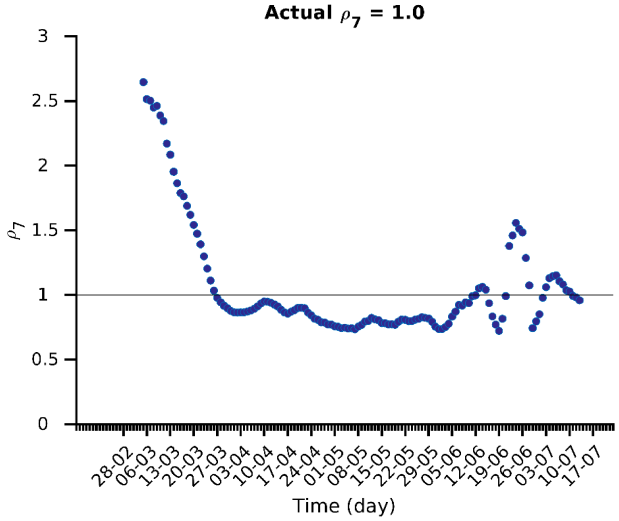
Italy 17-07-2020. Pop: 60.5M. Cumulative incidence: 404/10⁵

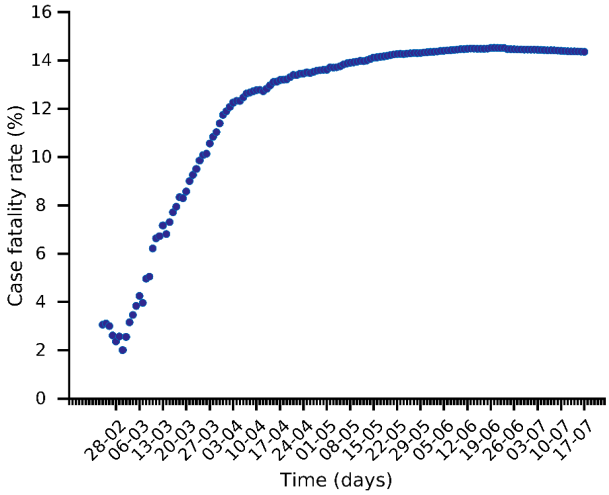


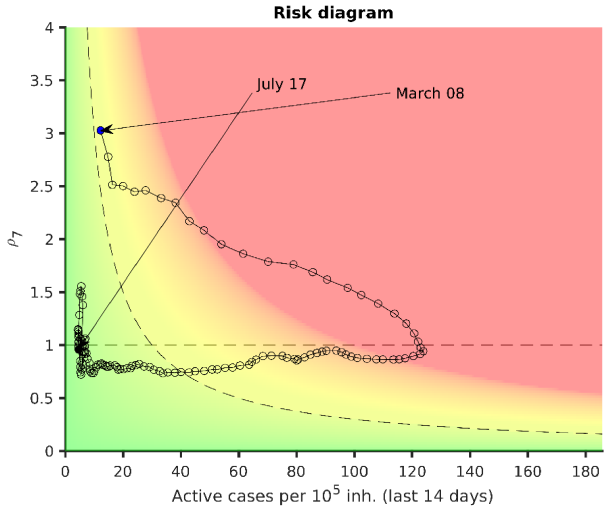


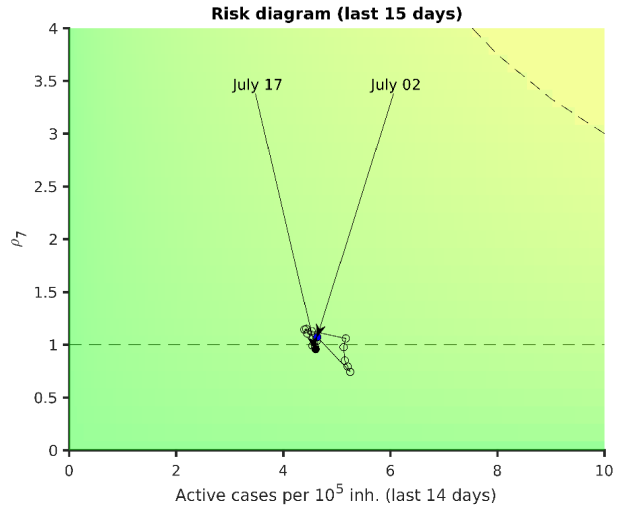




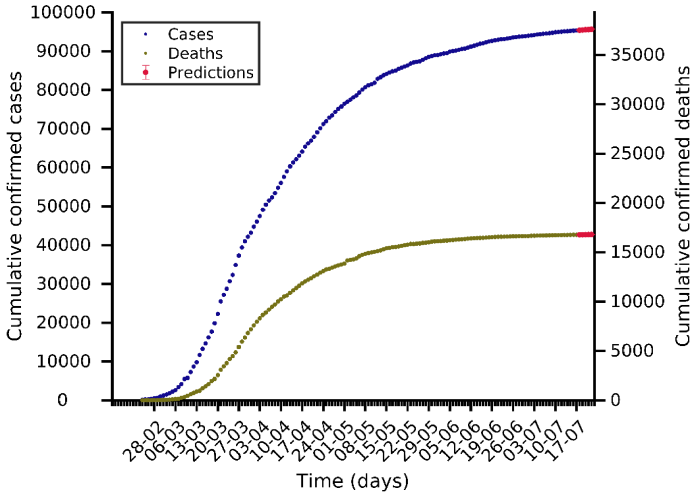


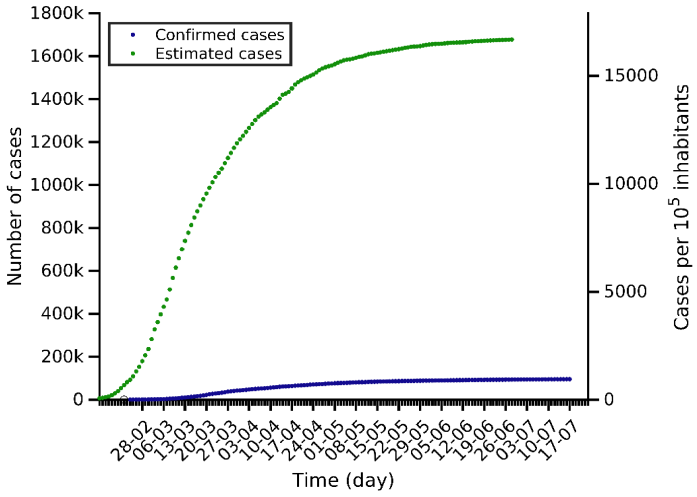


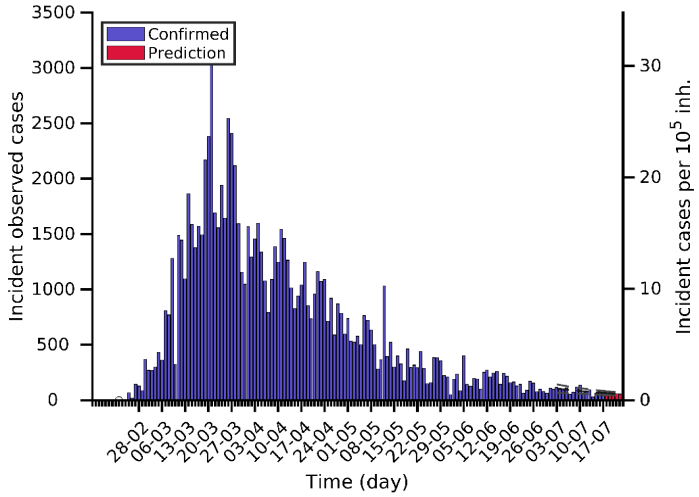


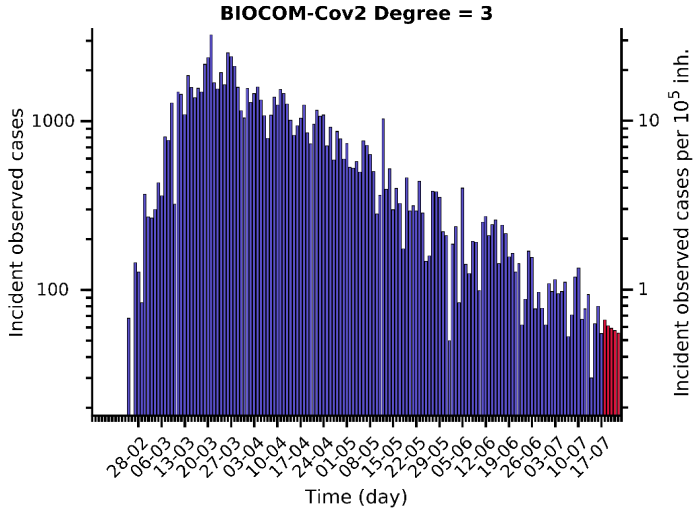


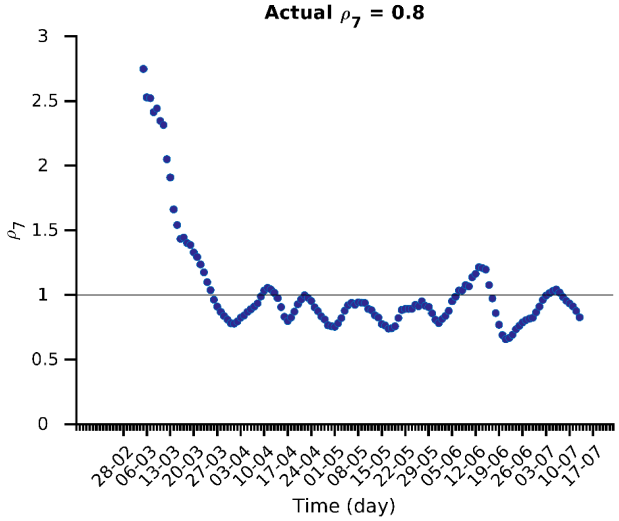
Lombardia 17-07-2020. Pop: 10.1M. Cumulative incidence: 948/10⁵

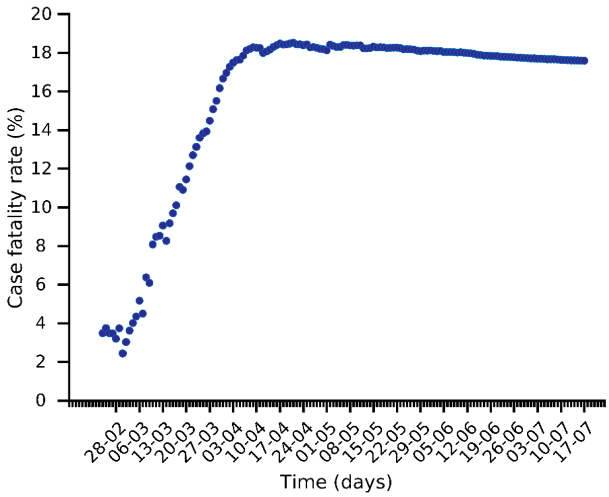


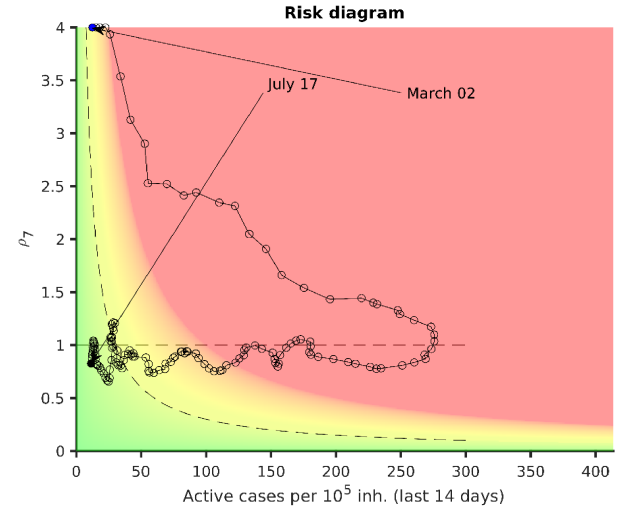


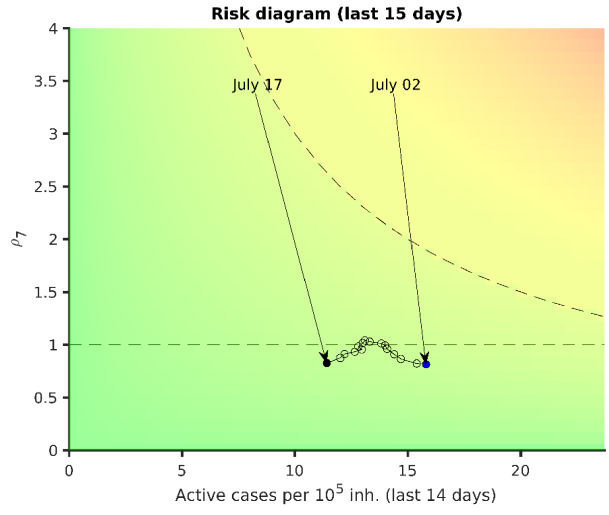




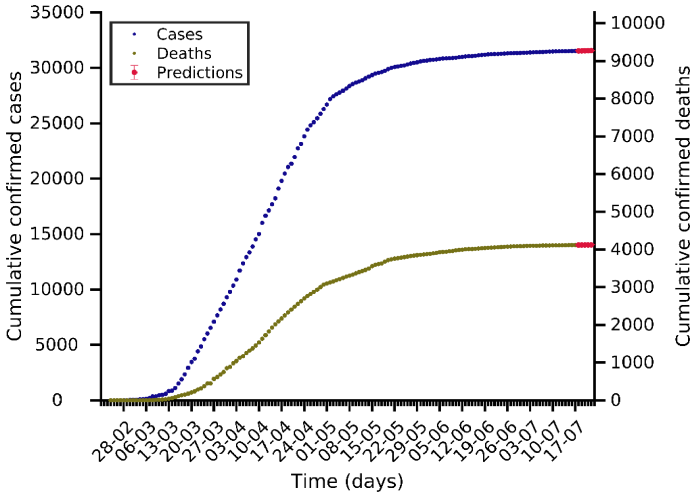


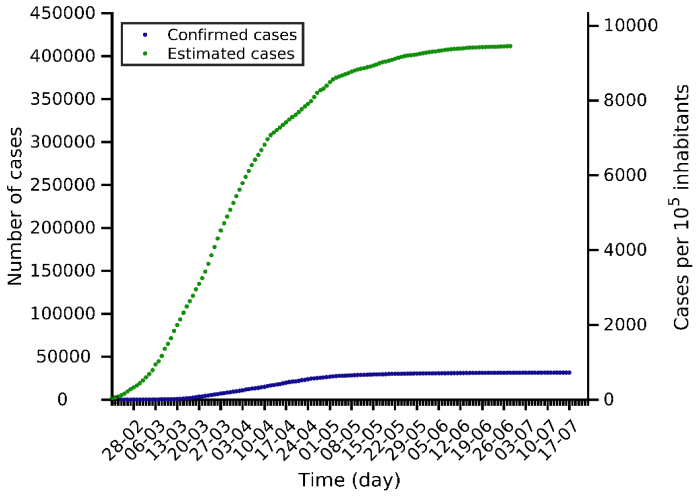


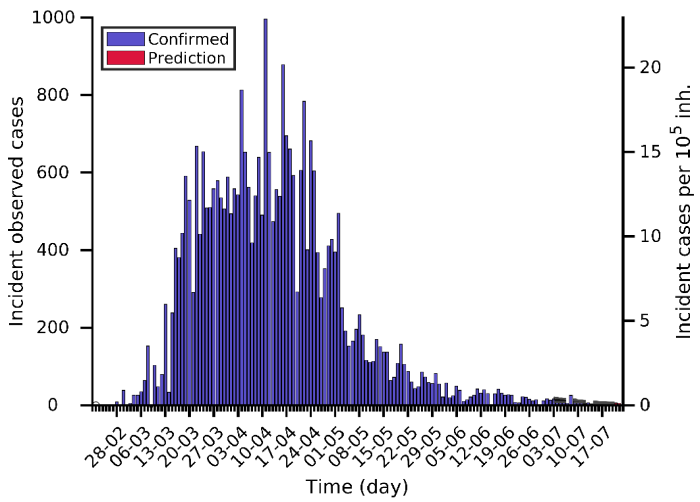


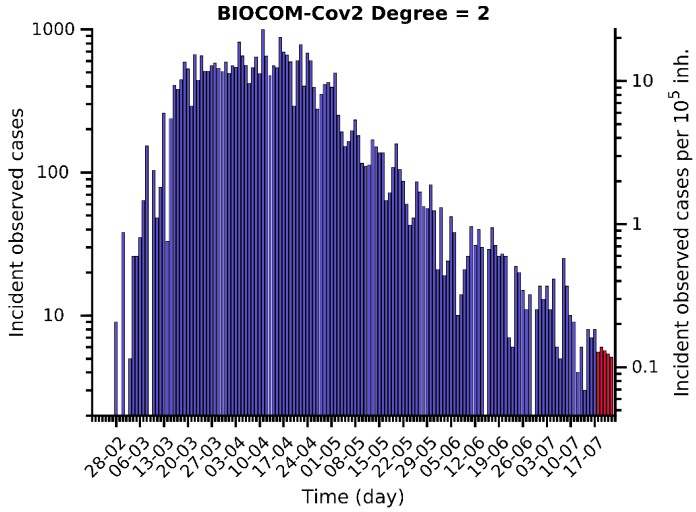


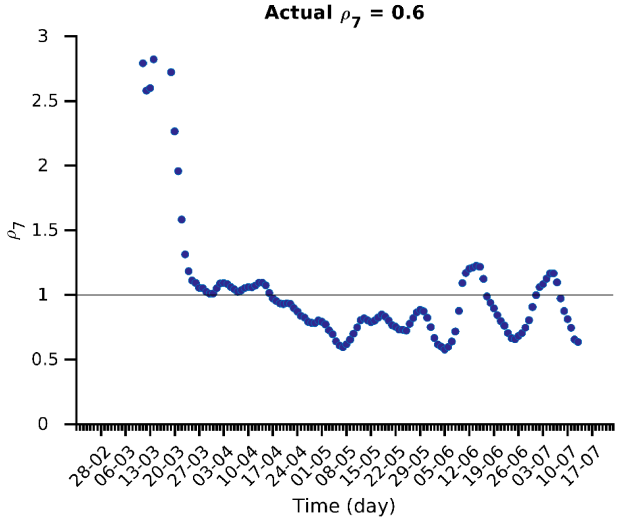
Piemonte 17-07-2020. Pop: 4.4M. Cumulative incidence: 724/10⁵

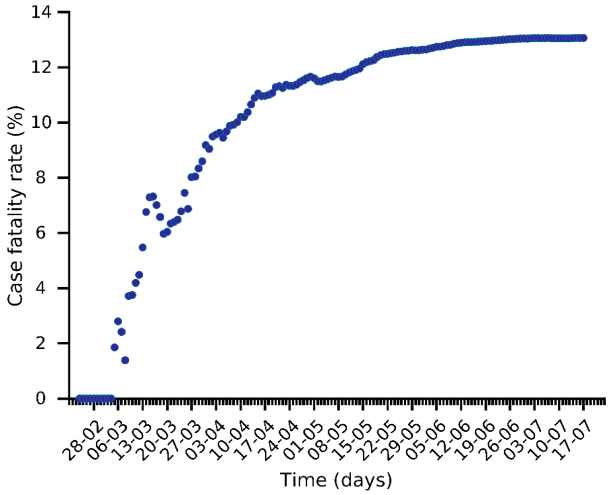


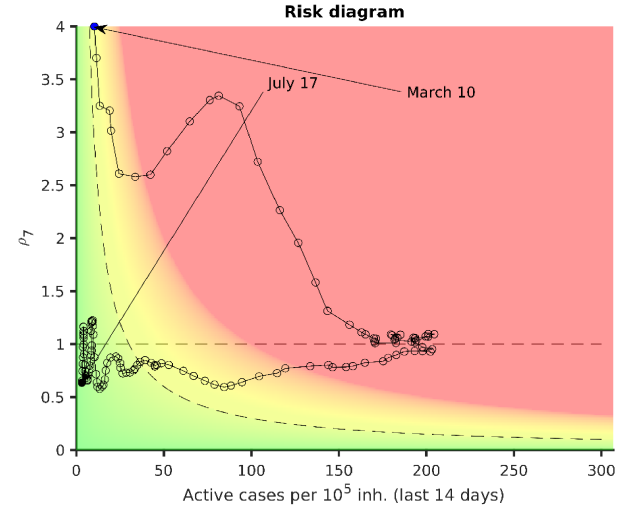


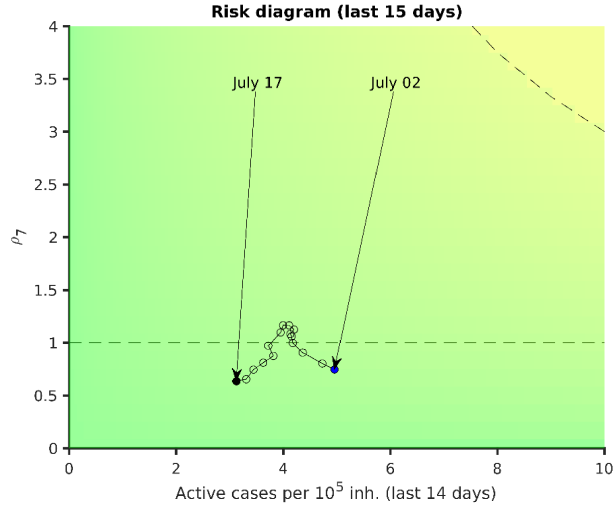




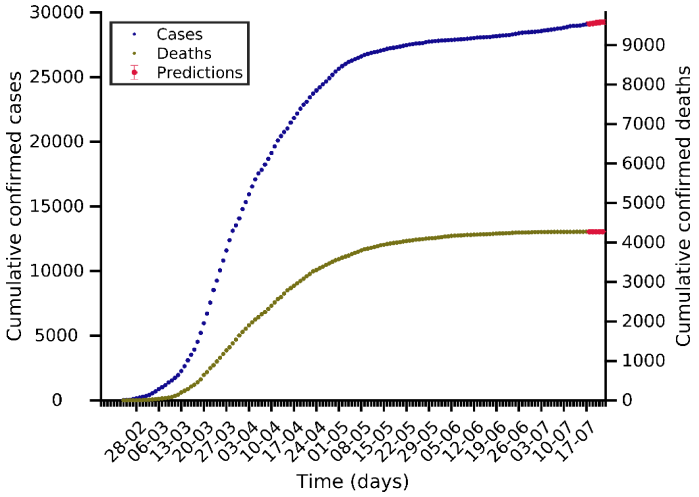


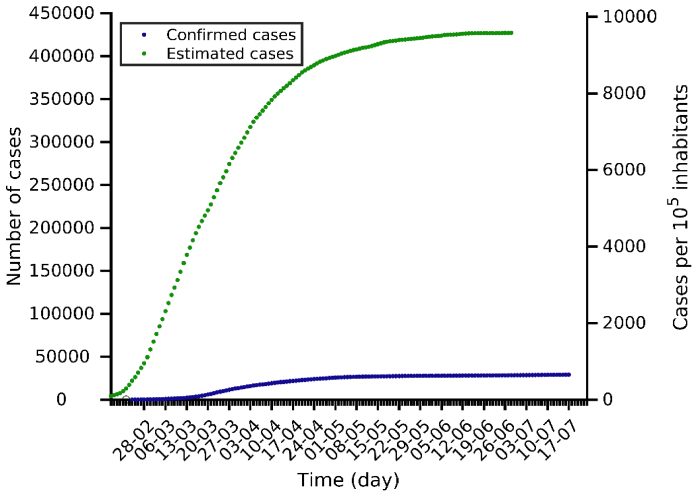


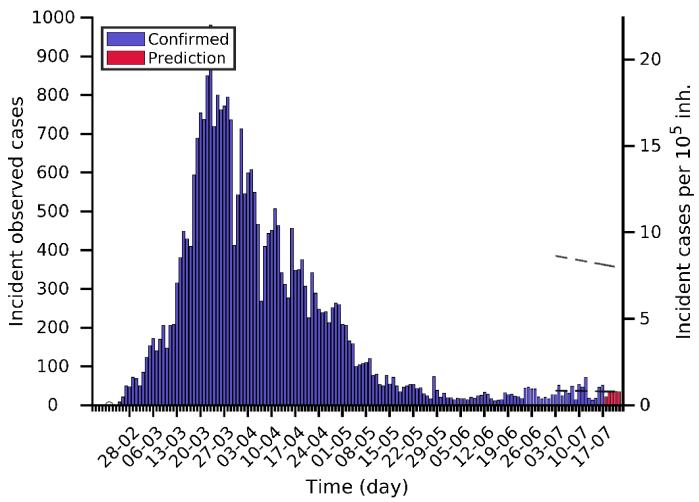


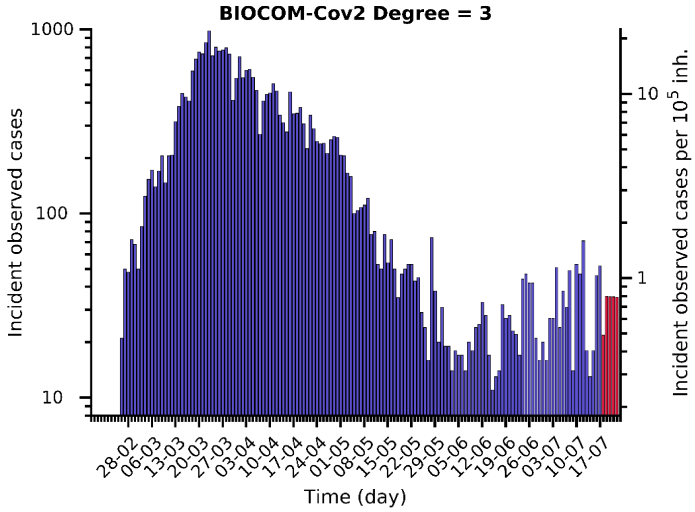


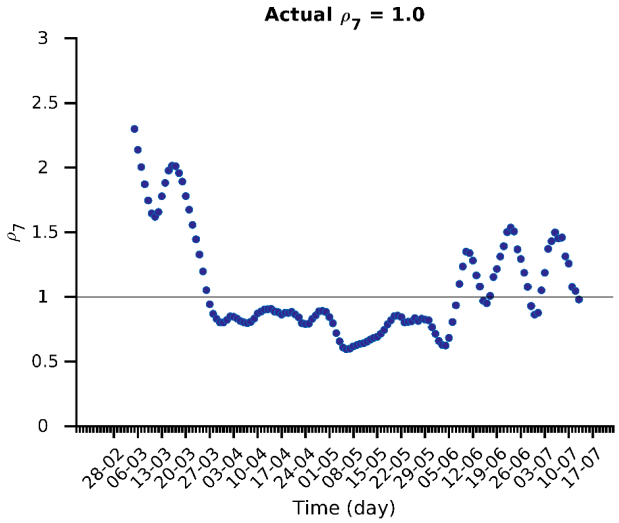
Emilia Romagna 17-07-2020. Pop: 4.5M. Cumulative incidence: 652/10⁵

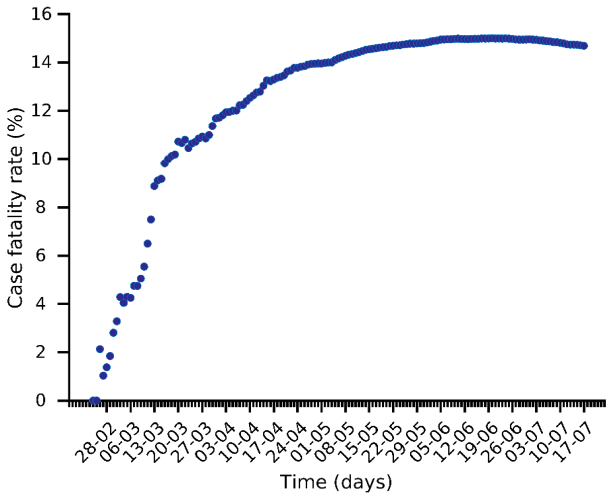


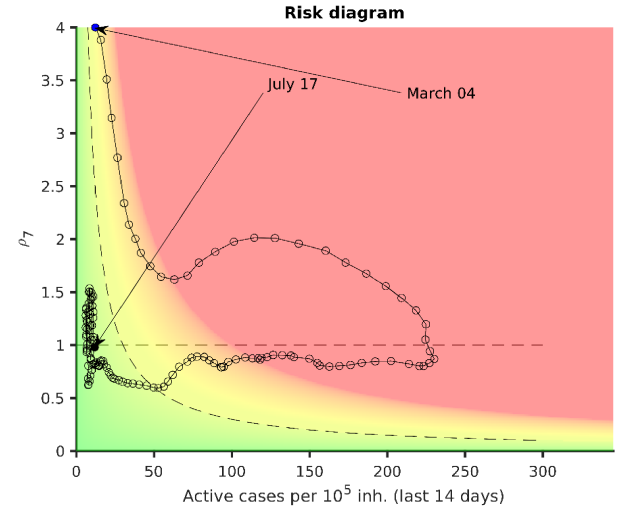


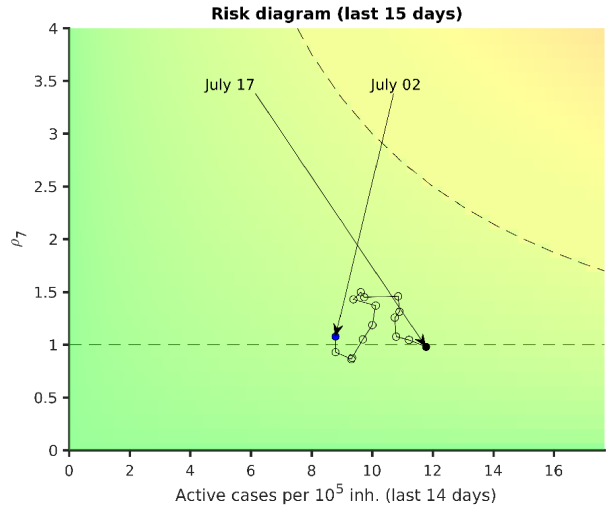




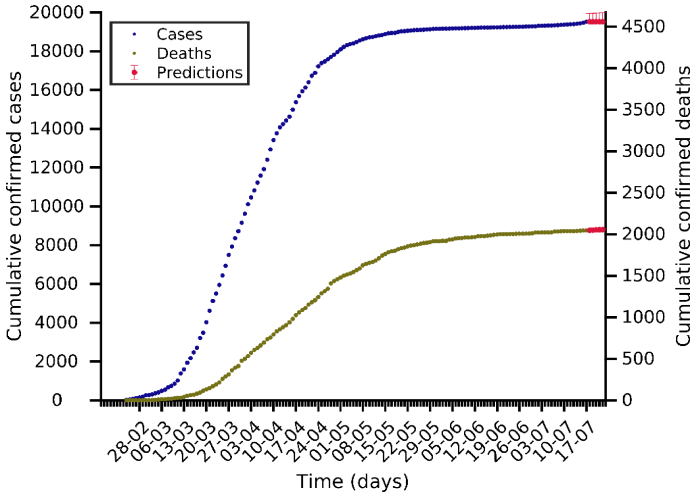


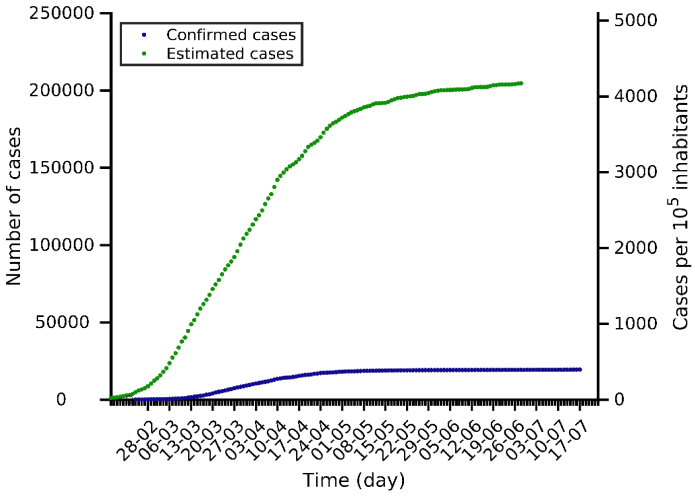


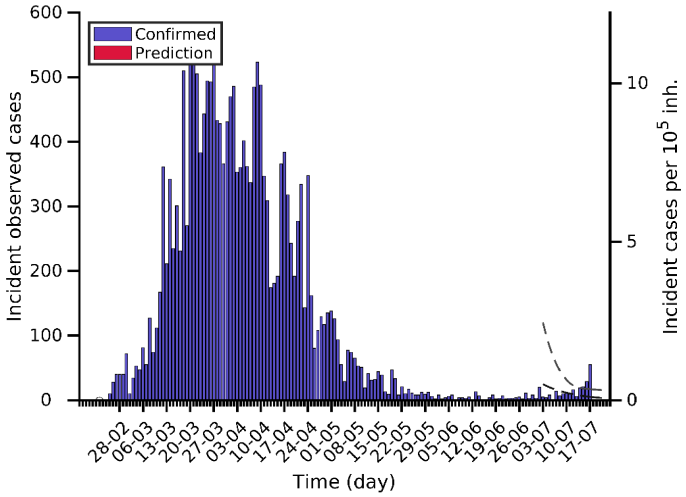


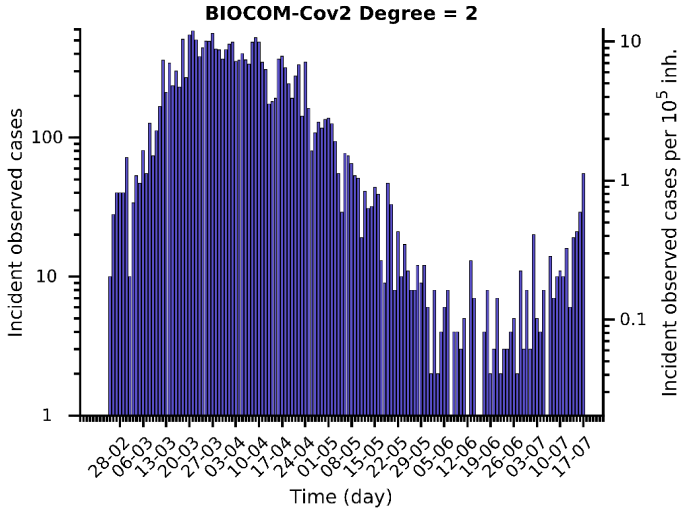


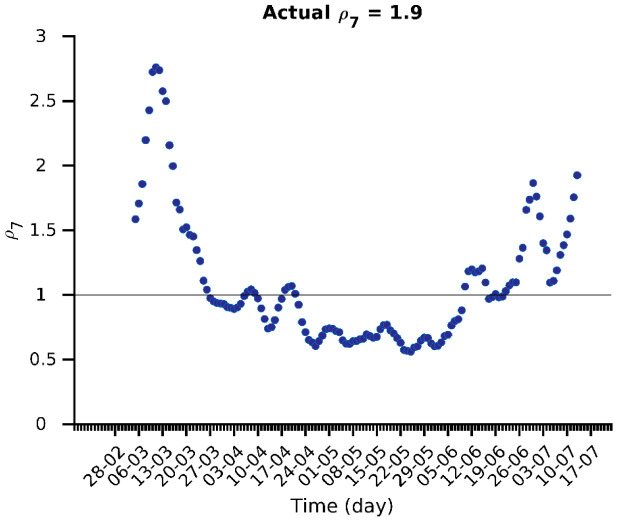
Veneto 17-07-2020. Pop: 4.9M. Cumulative incidence: 398/10⁵

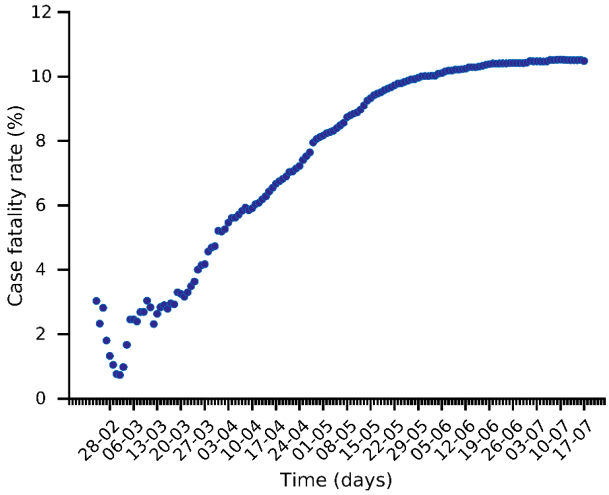


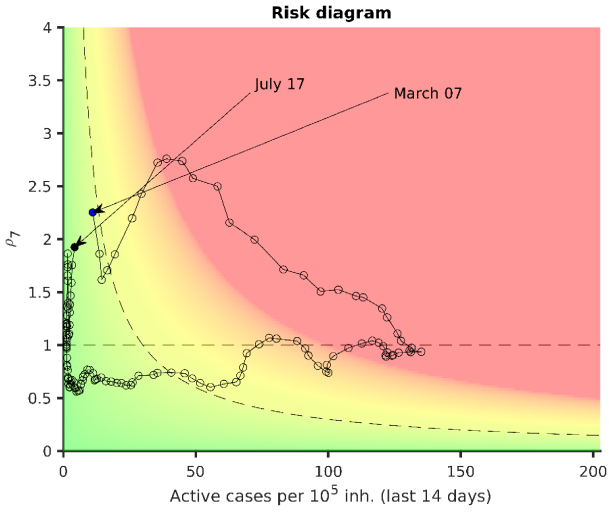


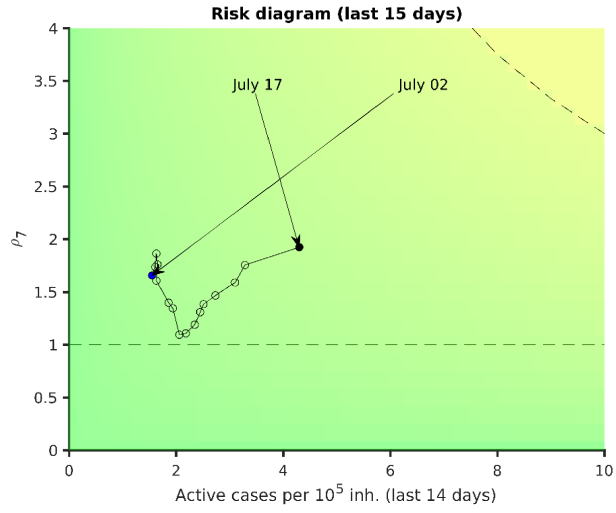




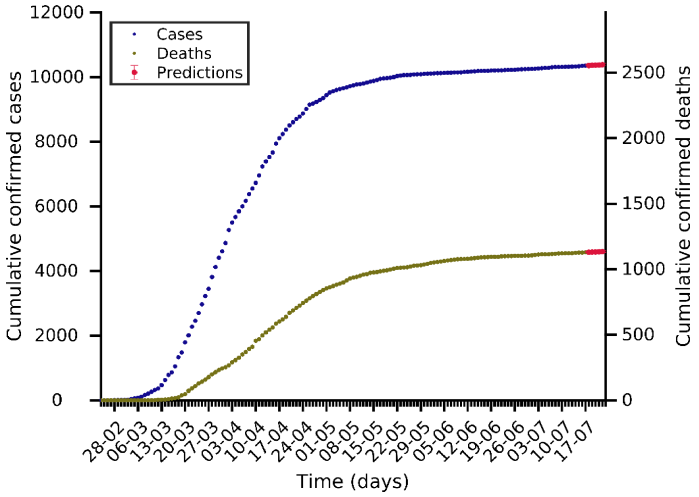


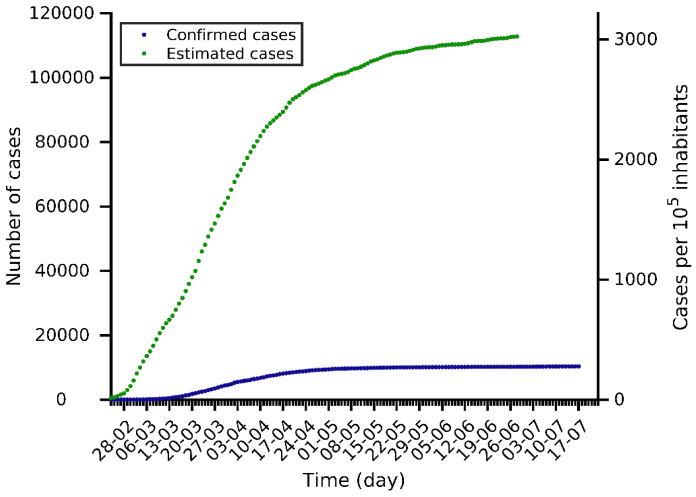


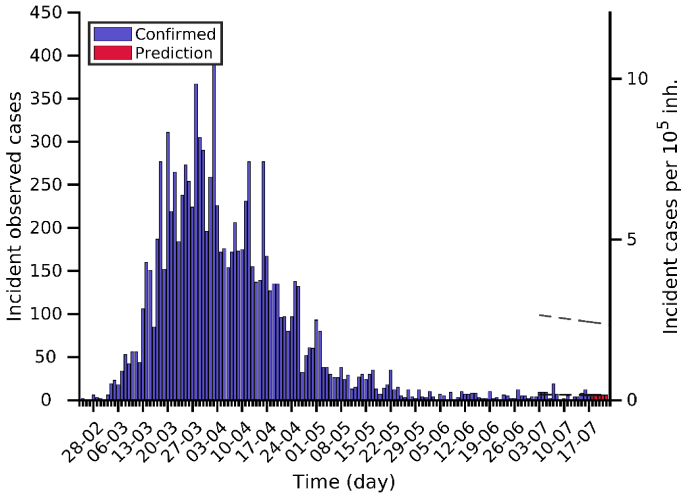


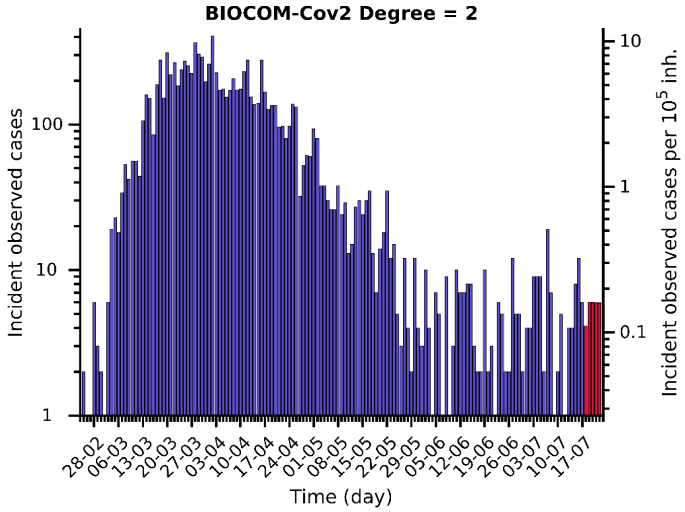


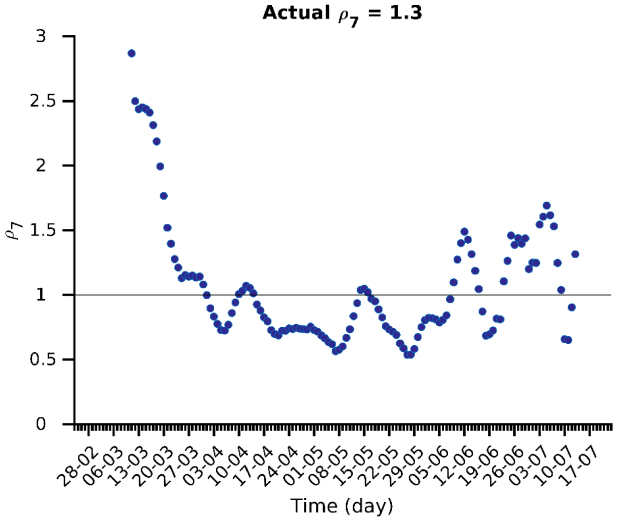
Toscana 17-07-2020. Pop: 3.7M. Cumulative incidence: 278/10⁵

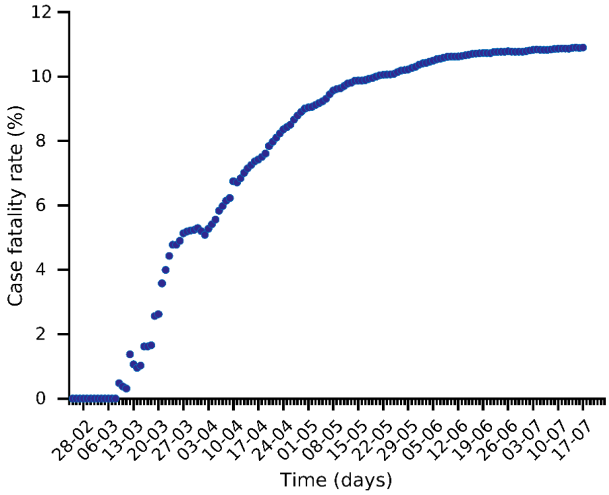


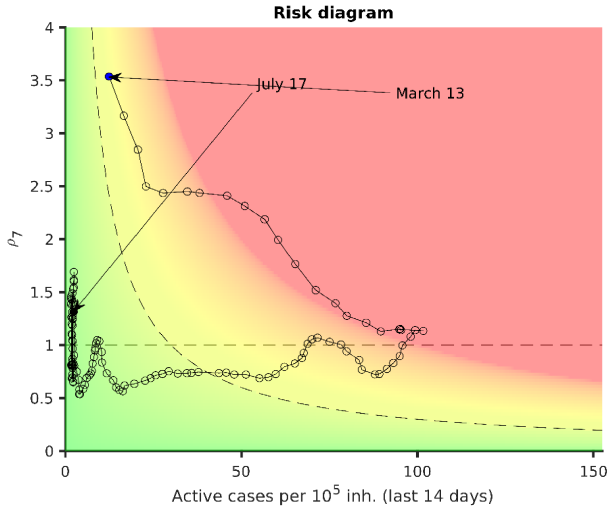


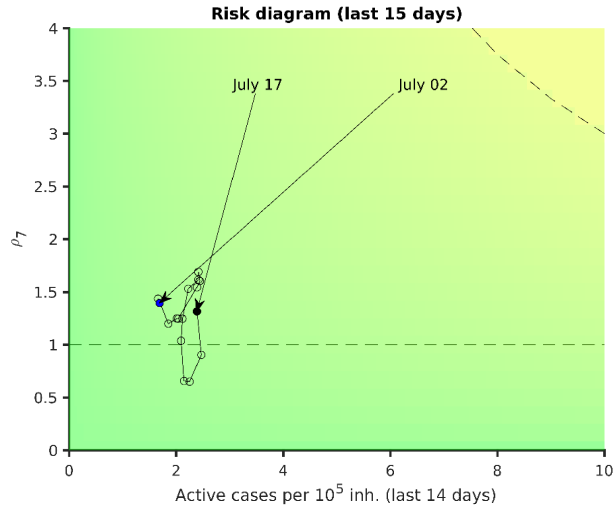




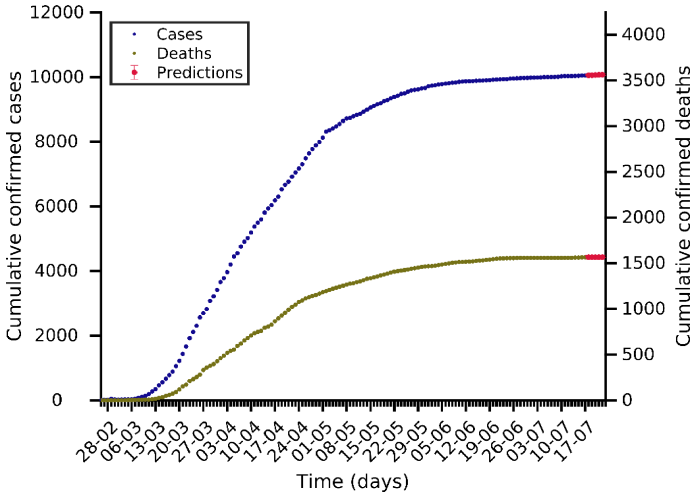


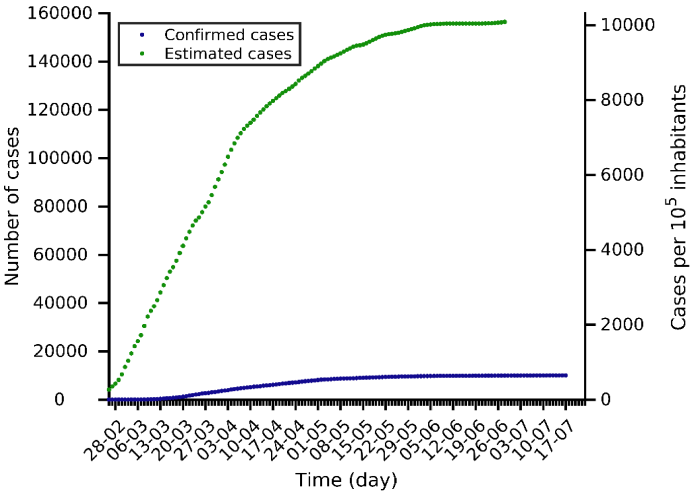


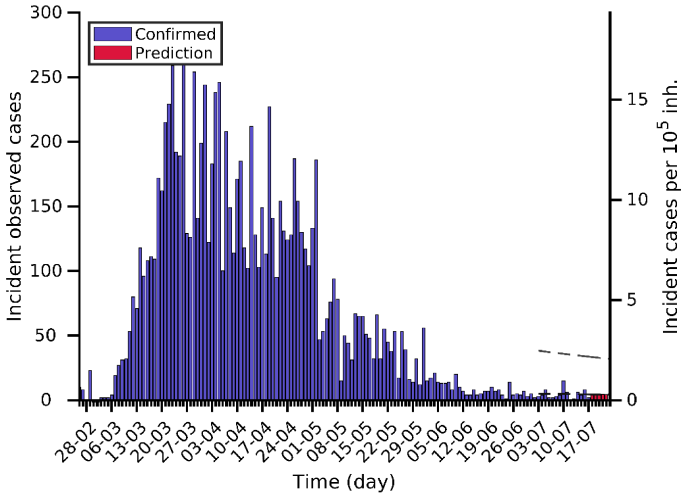


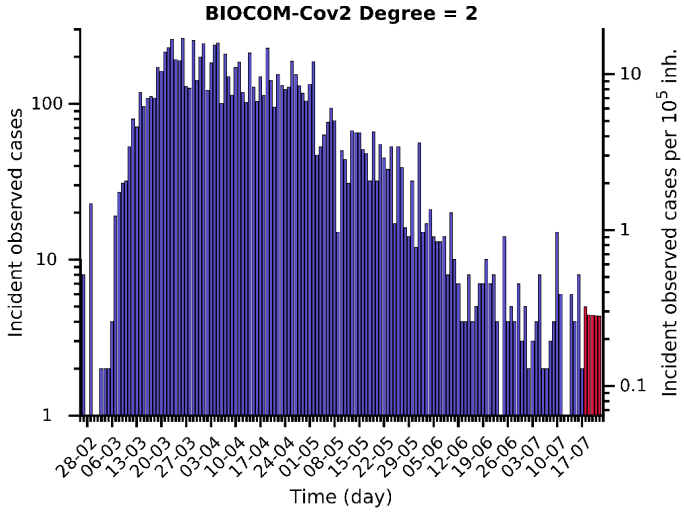


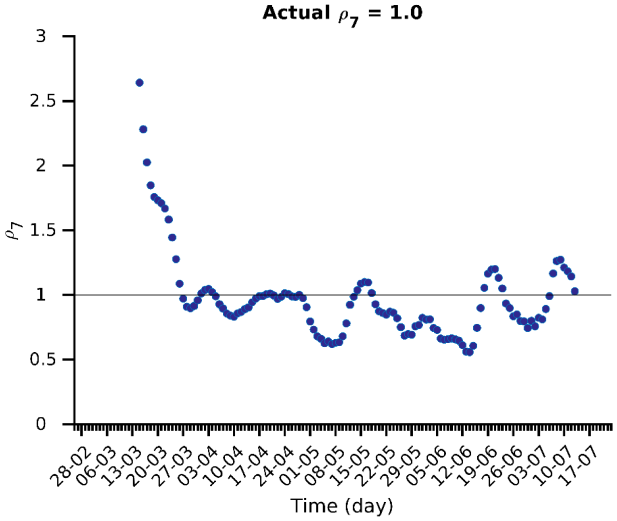
Liguria 17-07-2020. Pop: 1.6M. Cumulative incidence: 648/10⁵

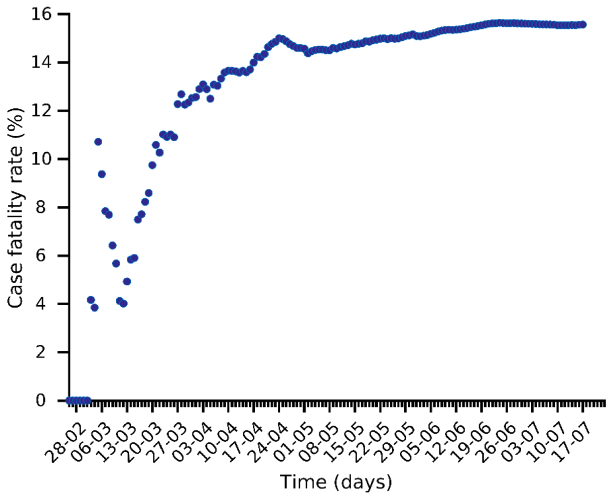


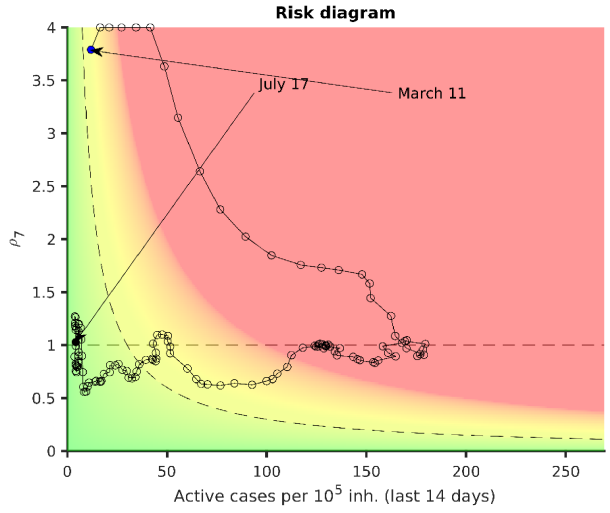


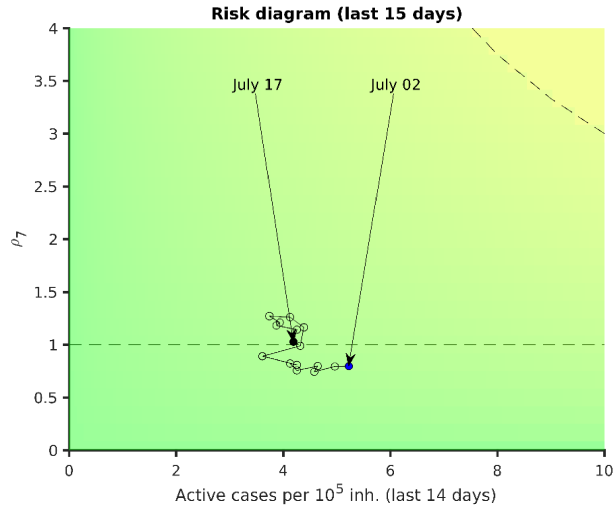




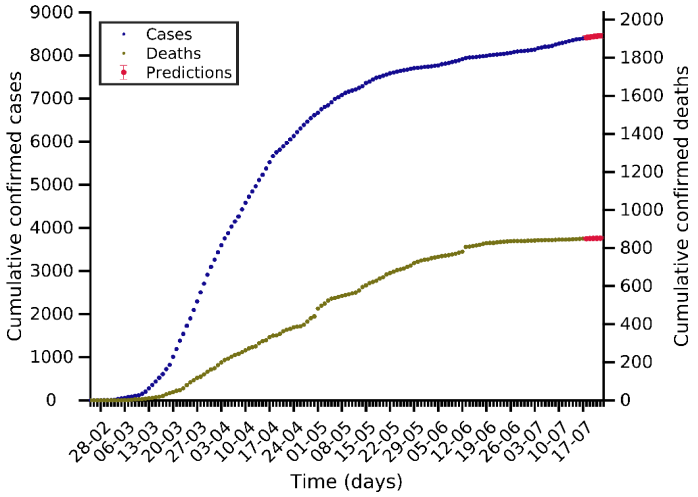


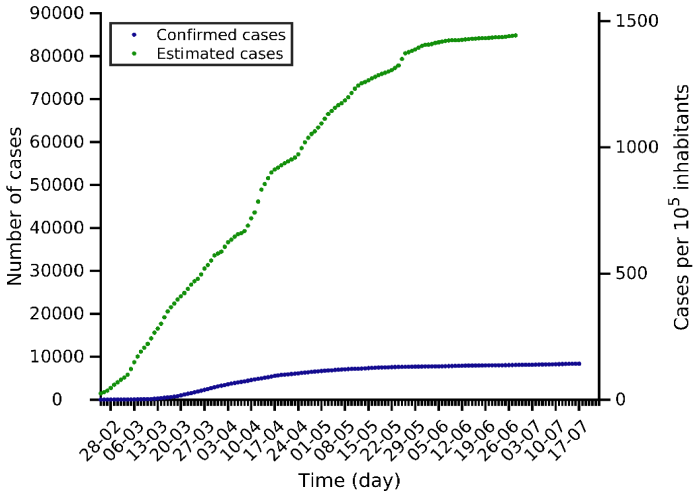


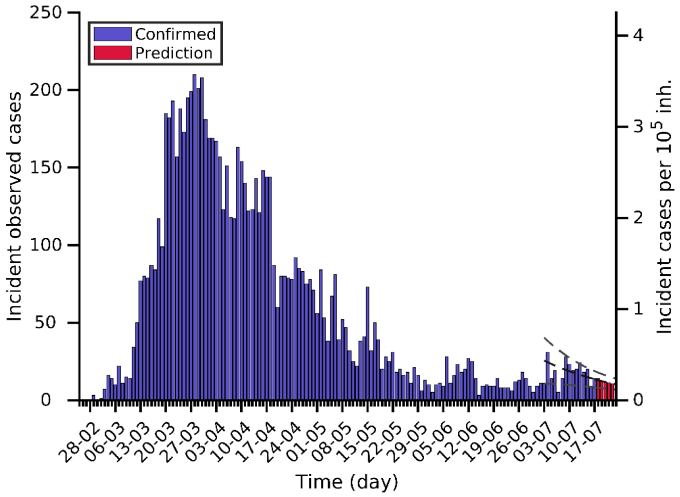


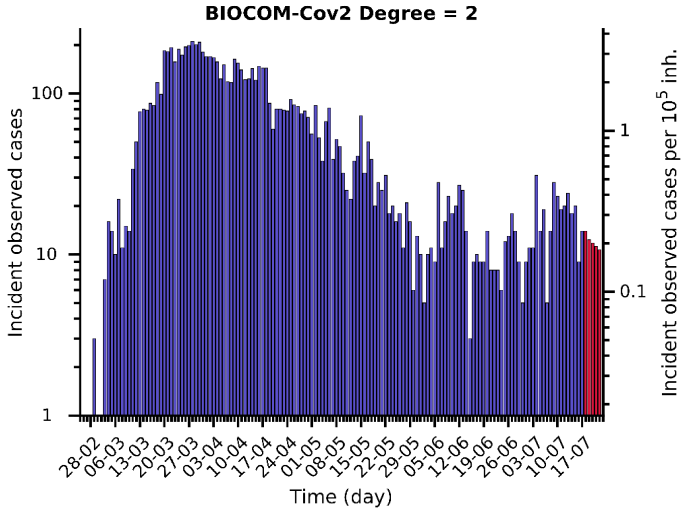


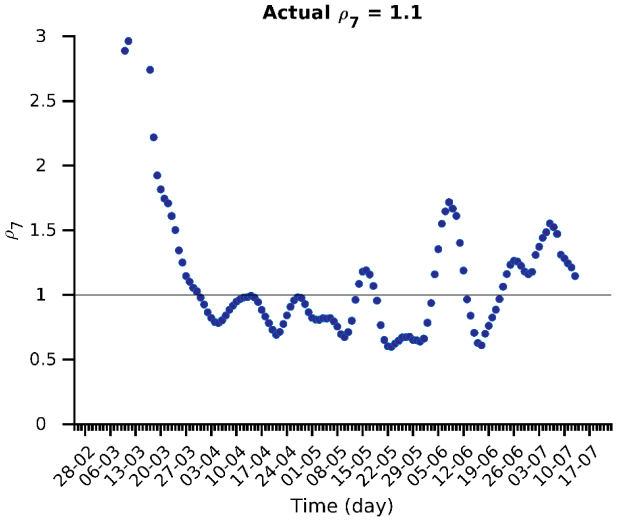
Lazio 17-07-2020. Pop: 5.9M. Cumulative incidence: 143/10⁵

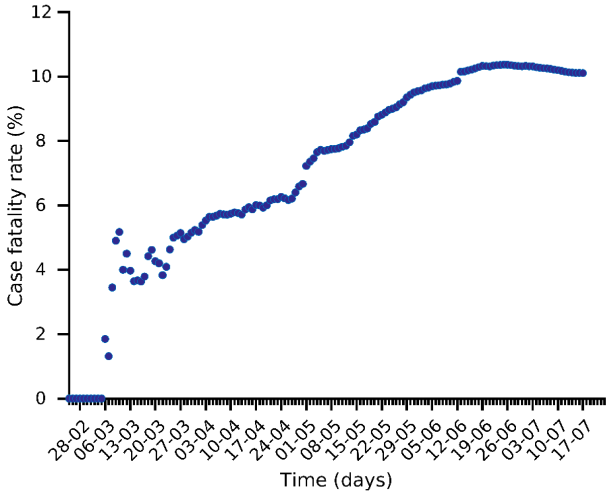


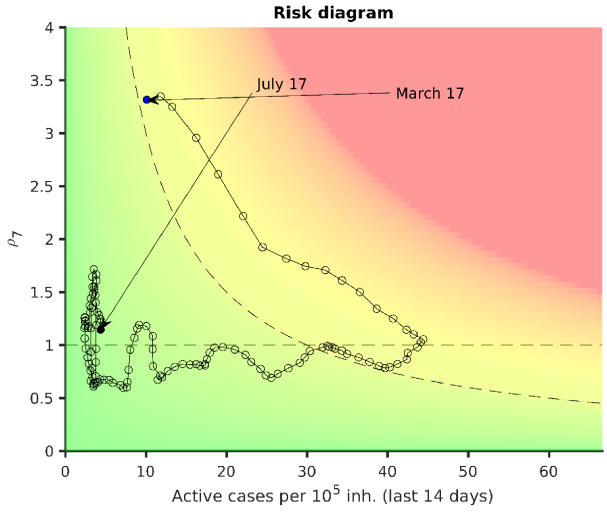


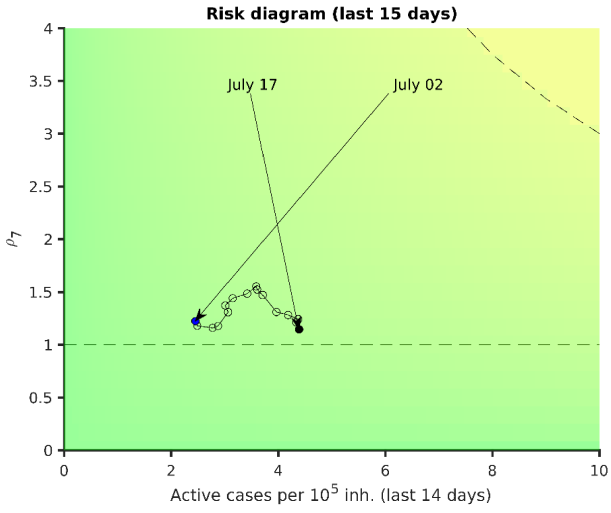




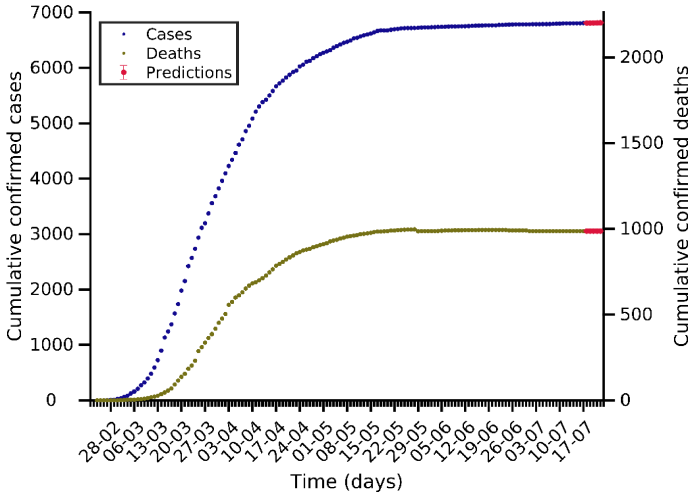


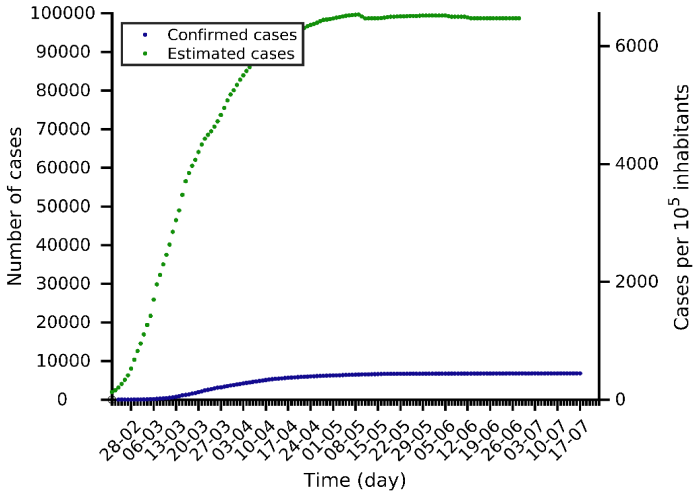


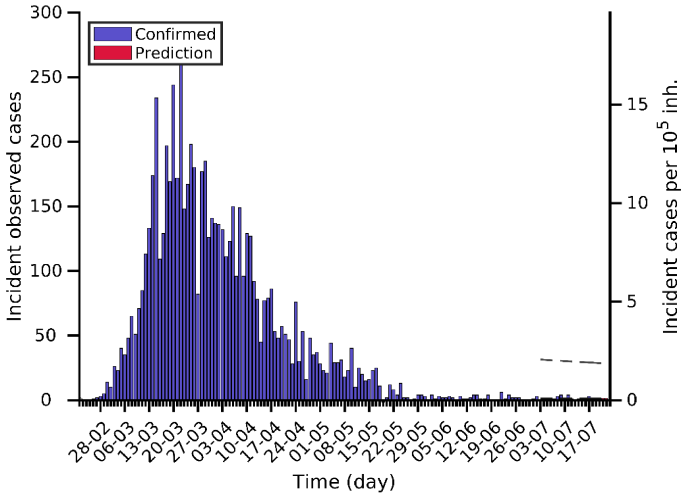


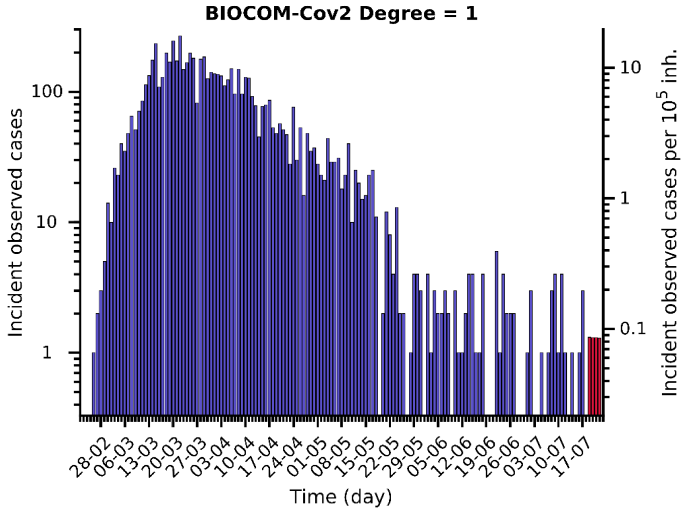


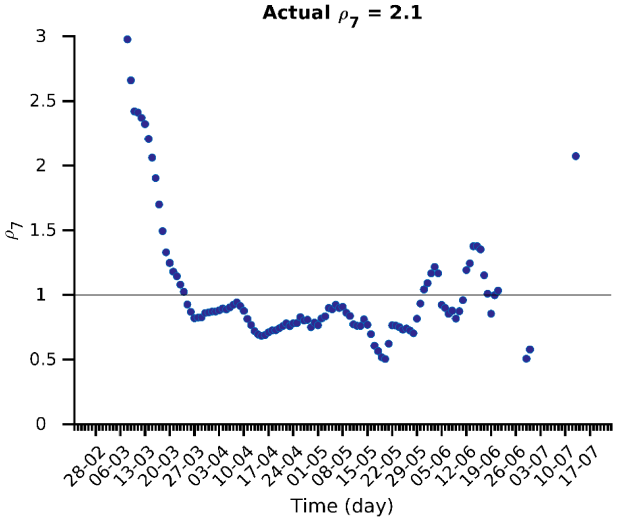
Marche 17-07-2020. Pop: 1.5M. Cumulative incidence: 446/10⁵

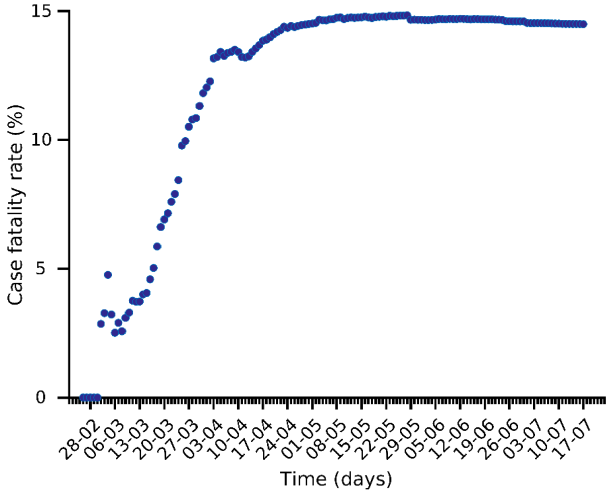


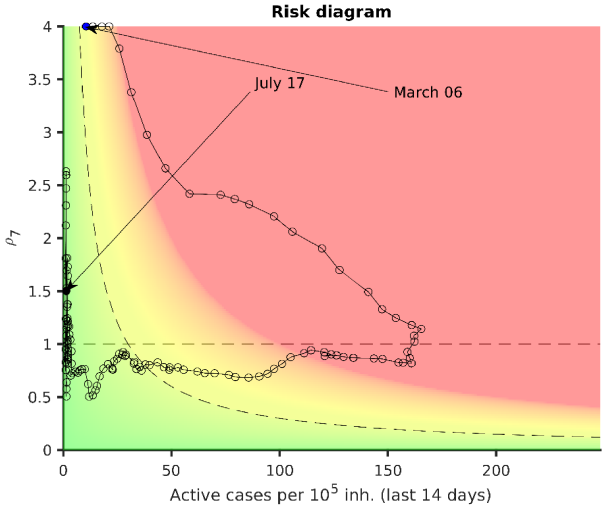


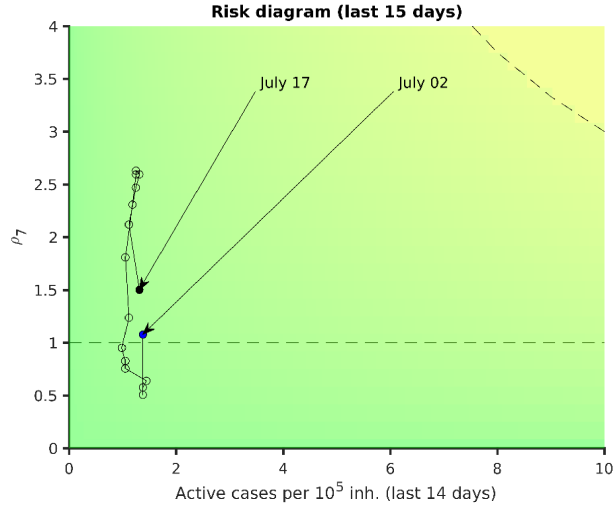




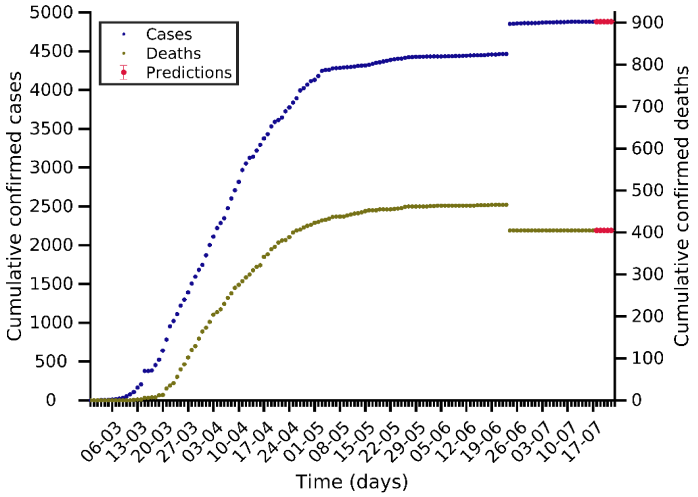


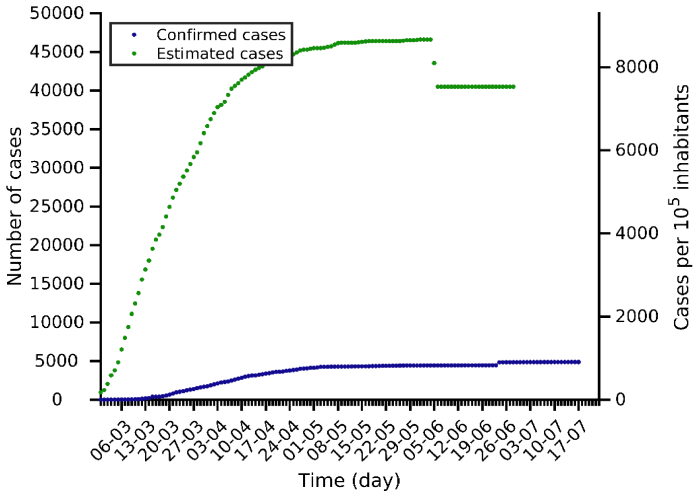


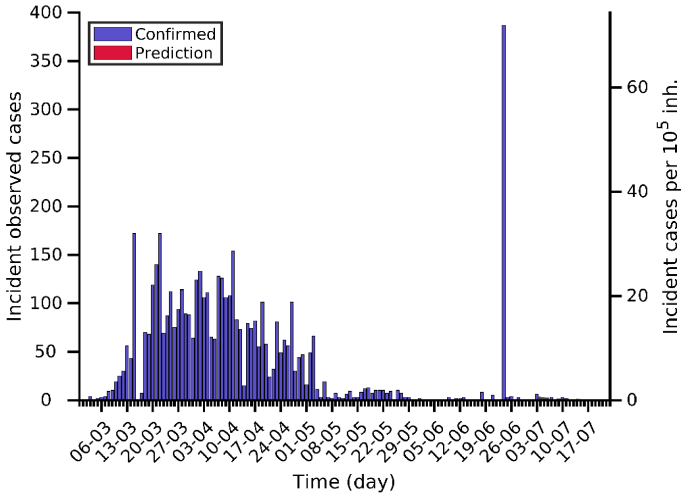


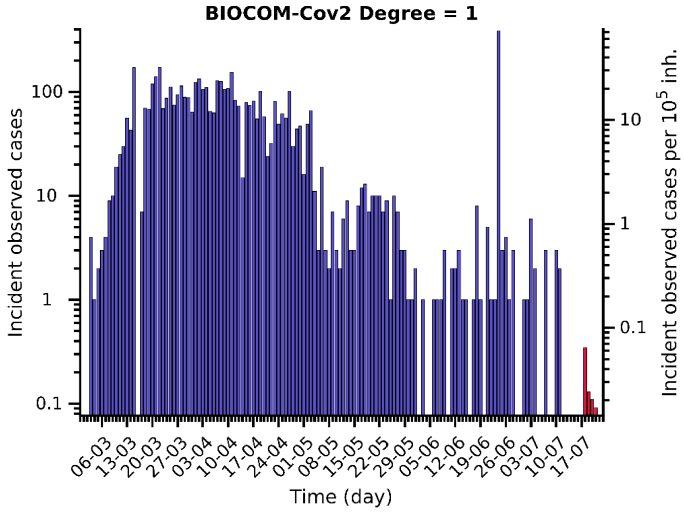


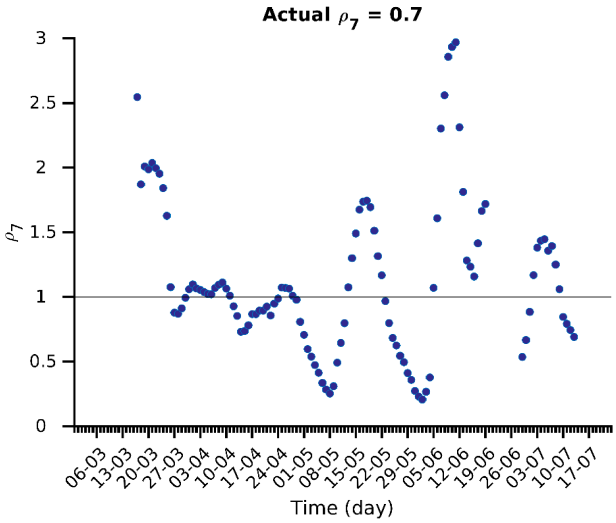
Trento 17-07-2020. Pop: 0.5M. Cumulative incidence: 907/10⁵

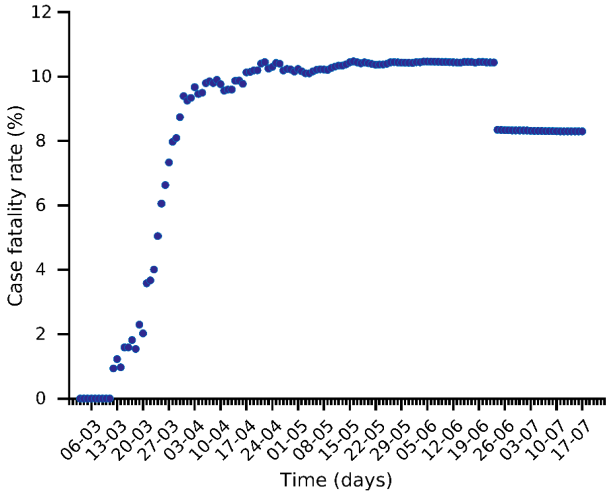


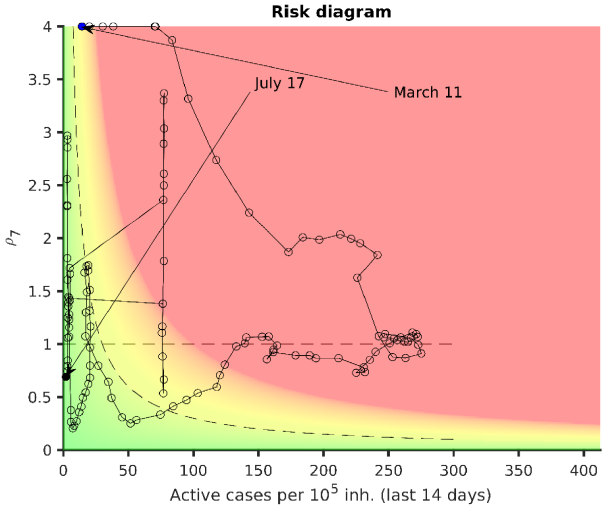


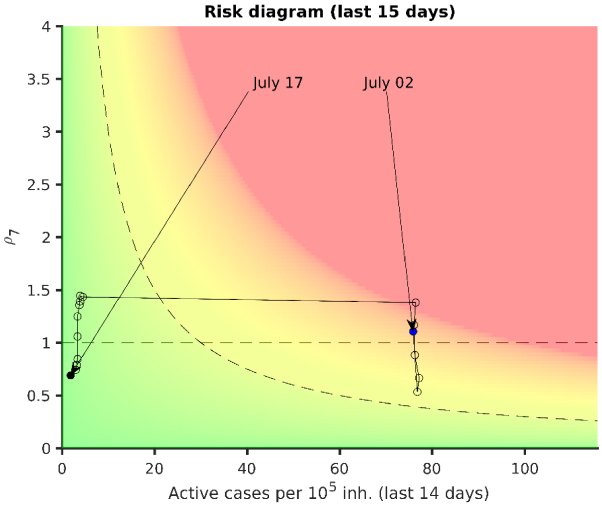




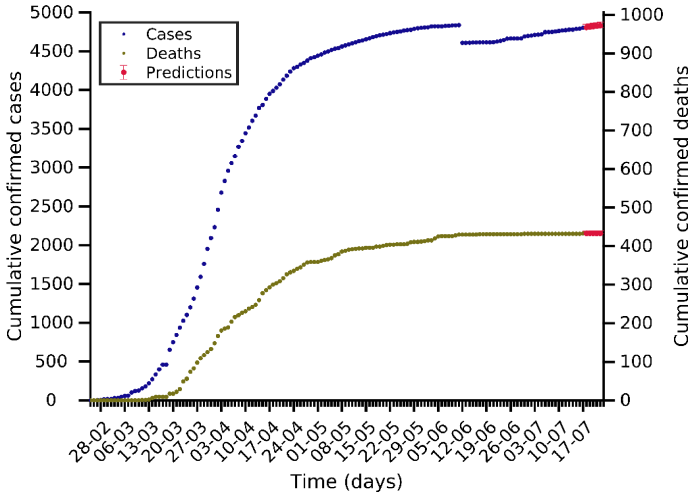


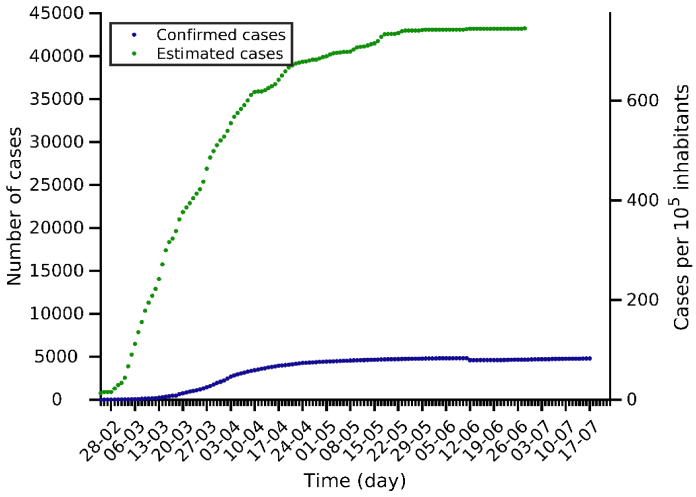


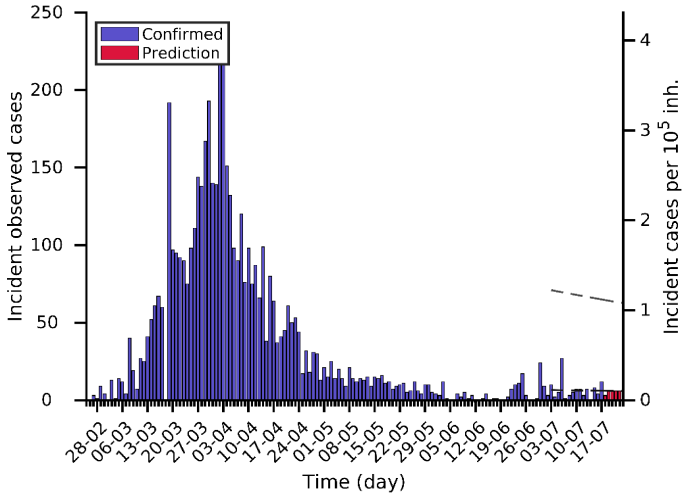


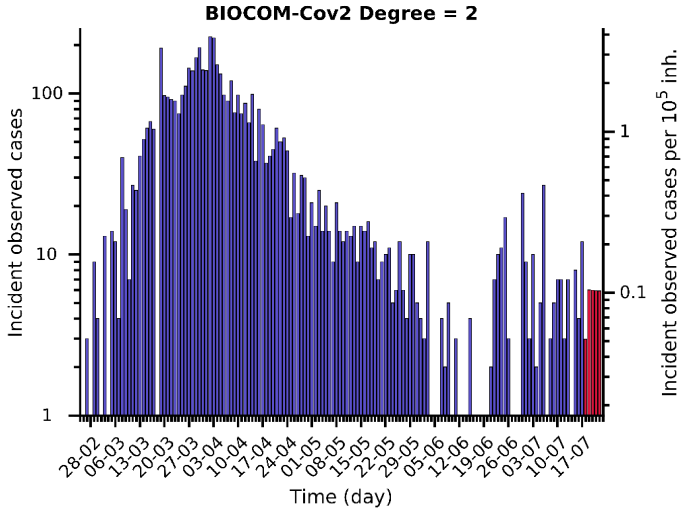


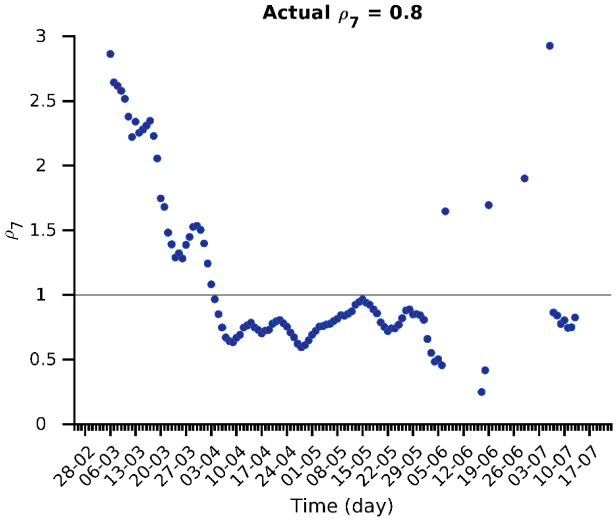
Campania 17-07-2020. Pop: 5.8M. Cumulative incidence: 83/10⁵

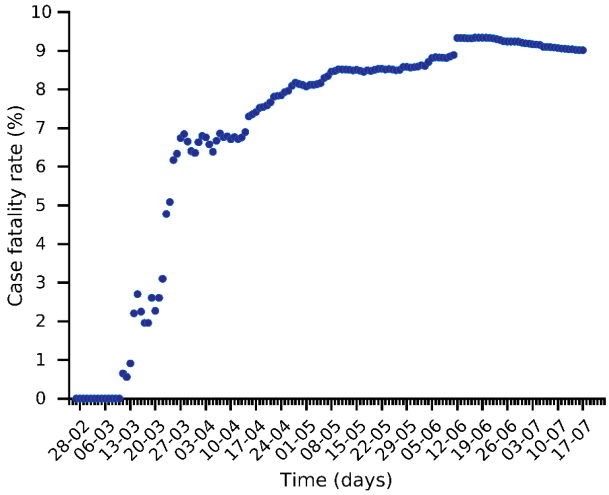


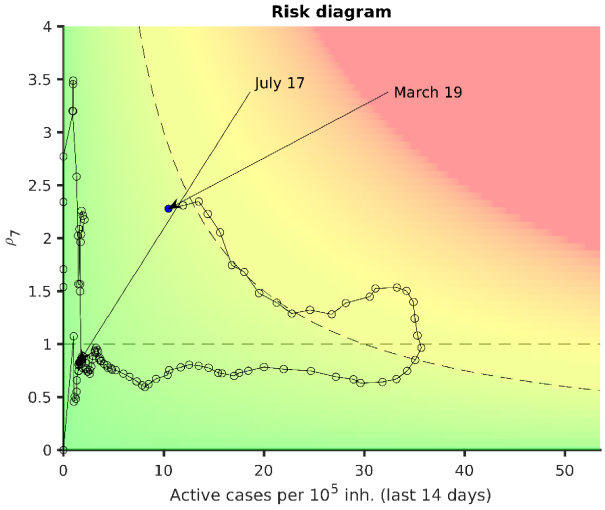


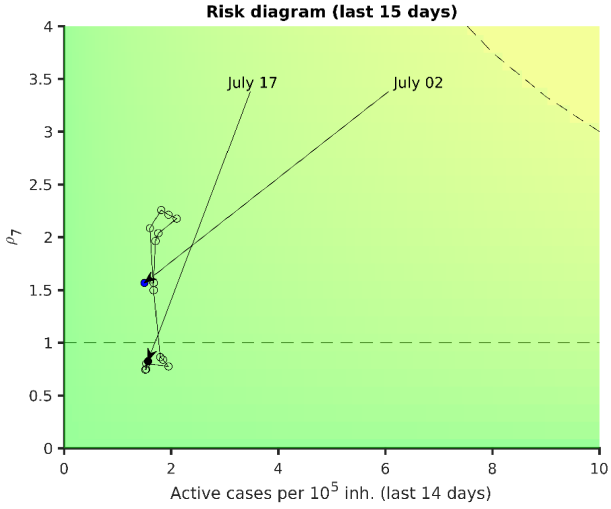




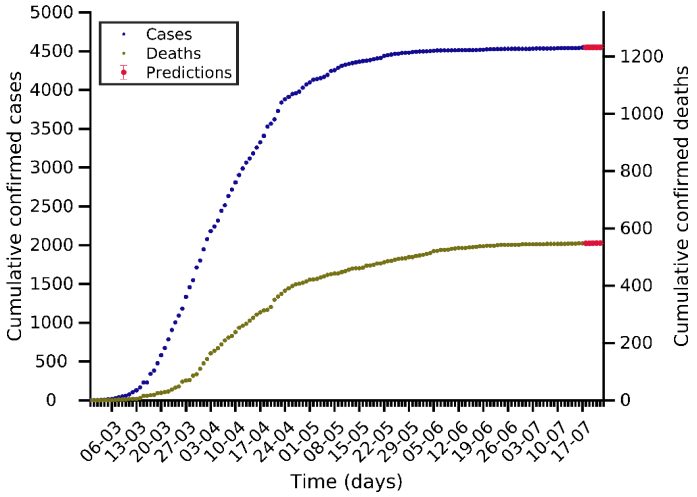


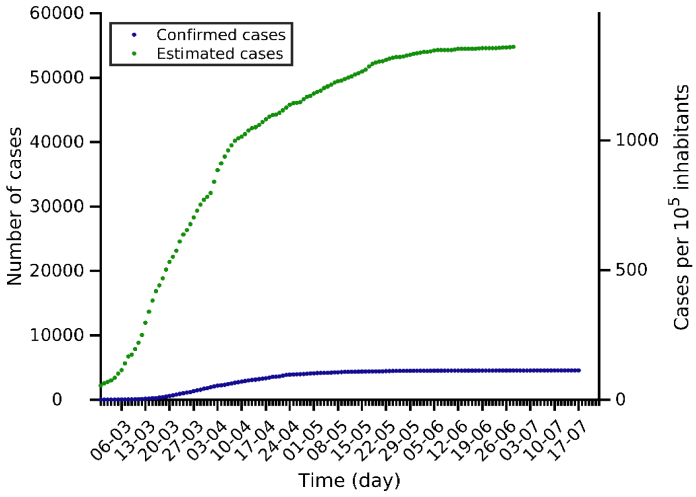


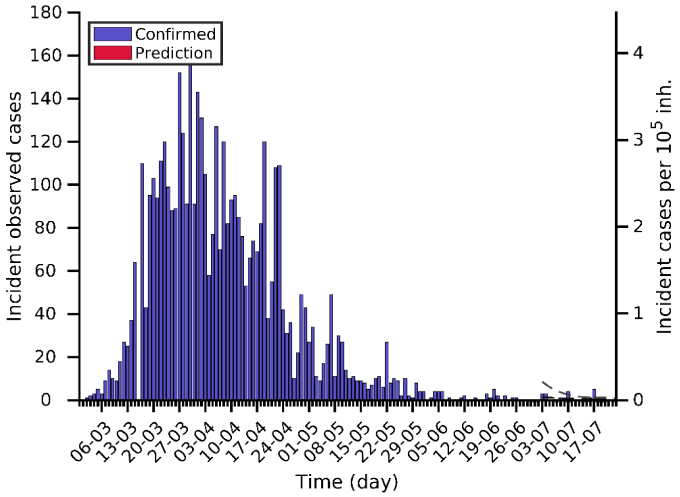


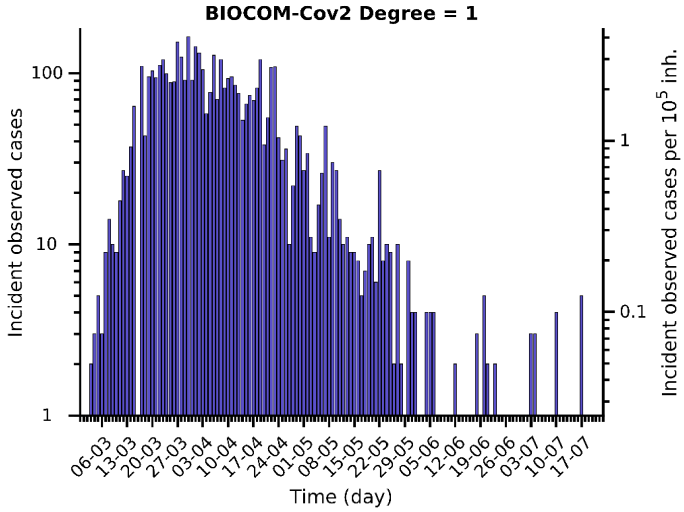


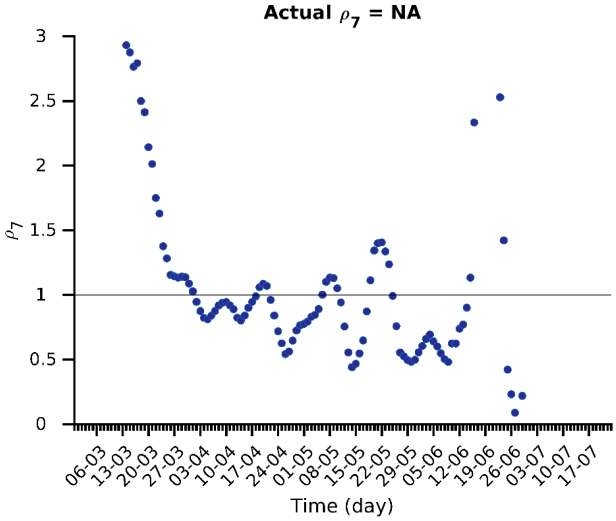
Puglia 17-07-2020. Pop: 4.0M. Cumulative incidence: 113/10⁵

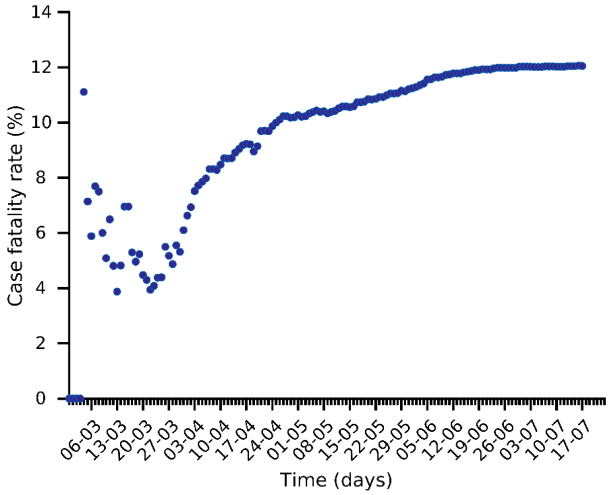


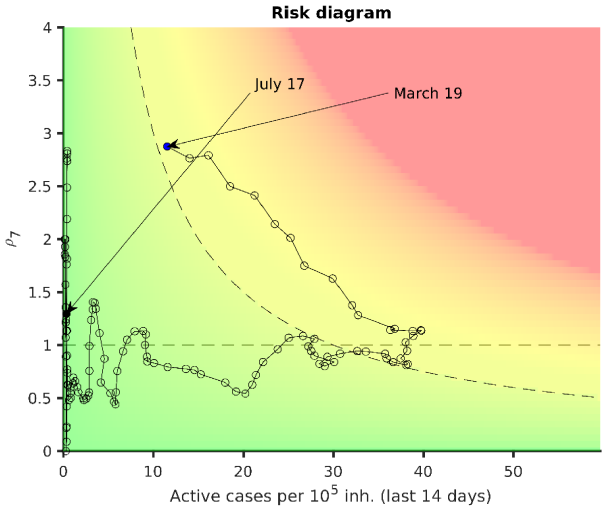


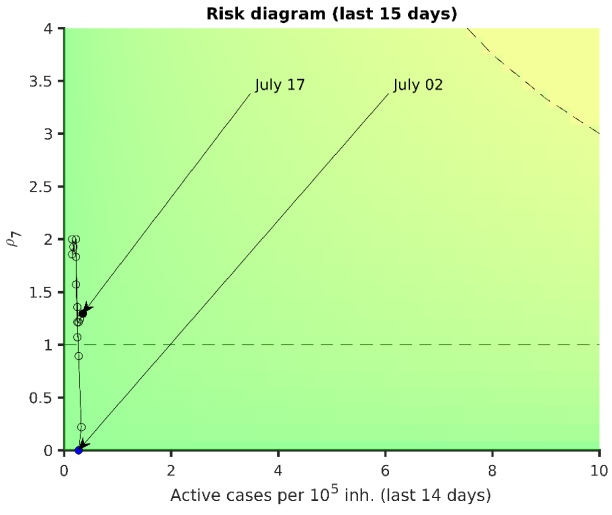




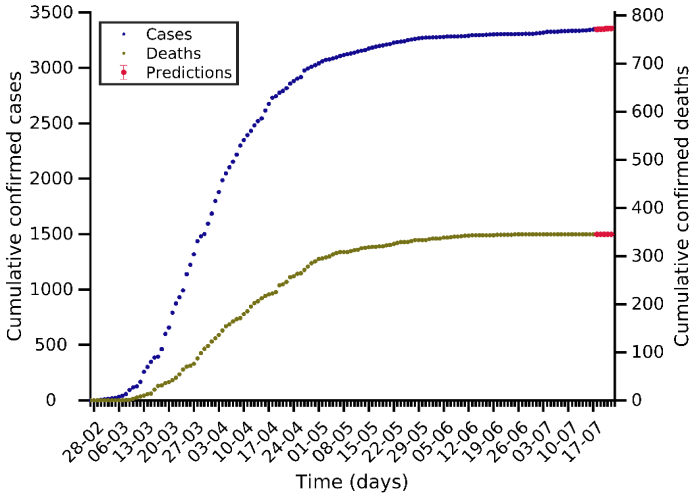


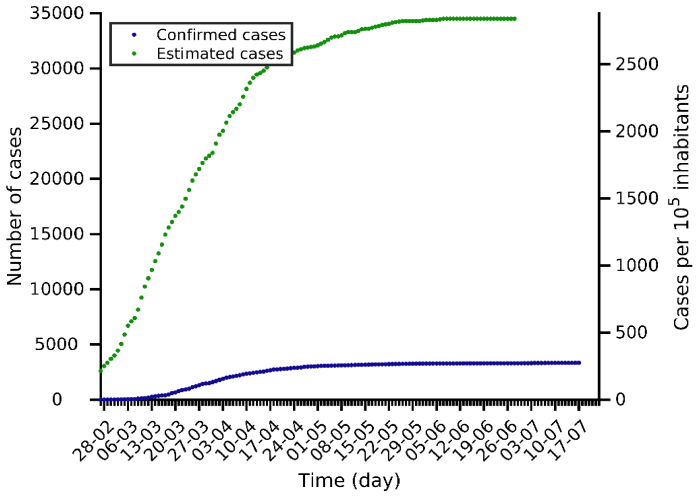


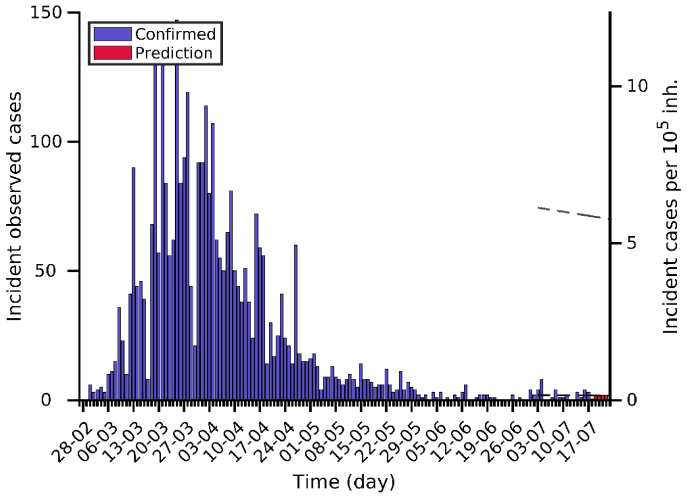


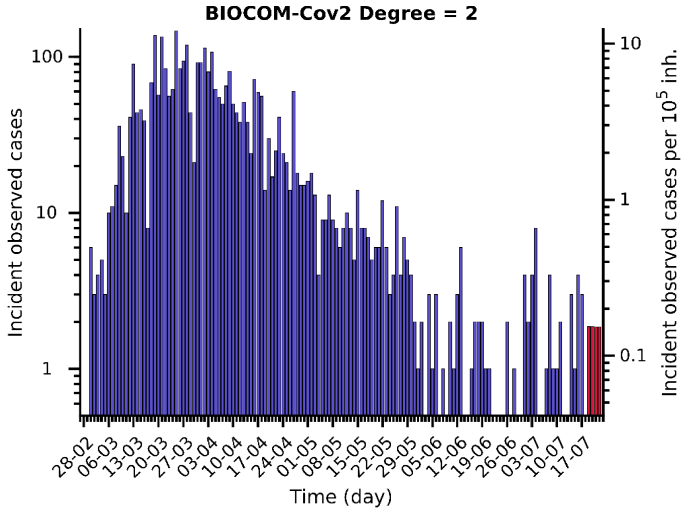


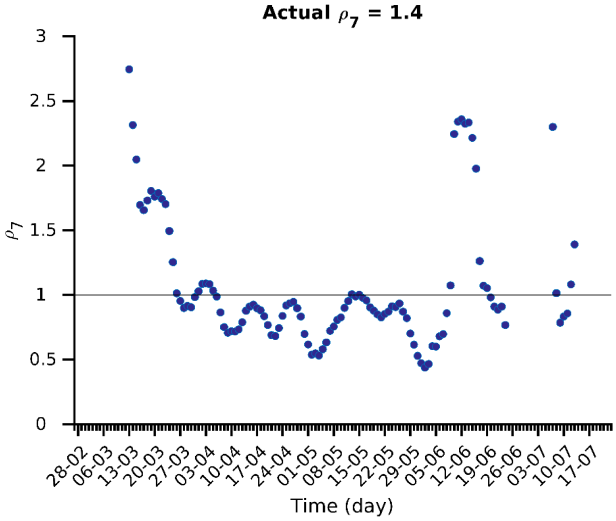
Friuli Venezia Giulia 17-07-2020. Pop: 1.2M. Cumulative incidence: 275/10⁵

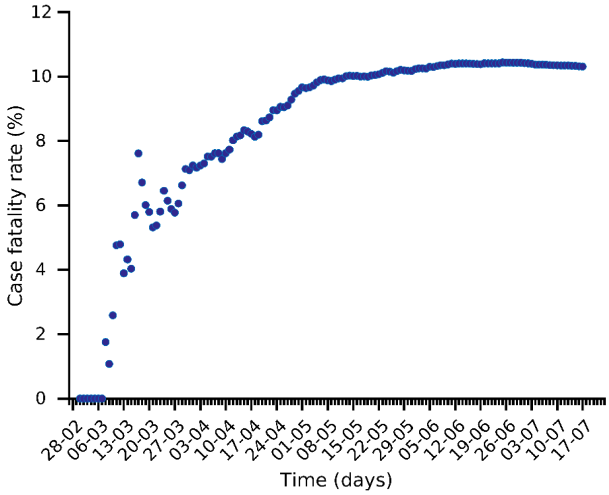


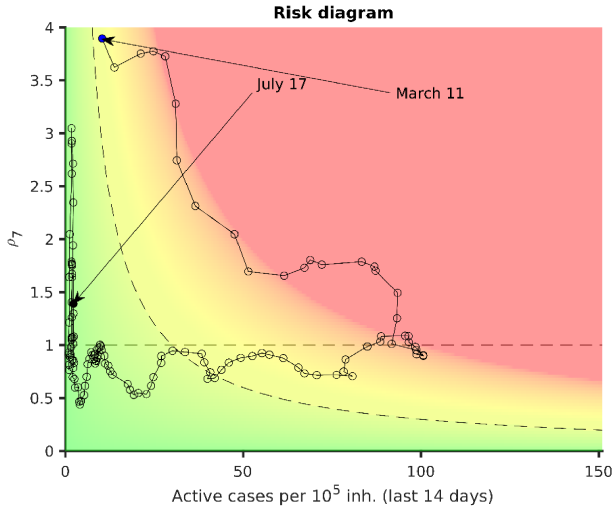


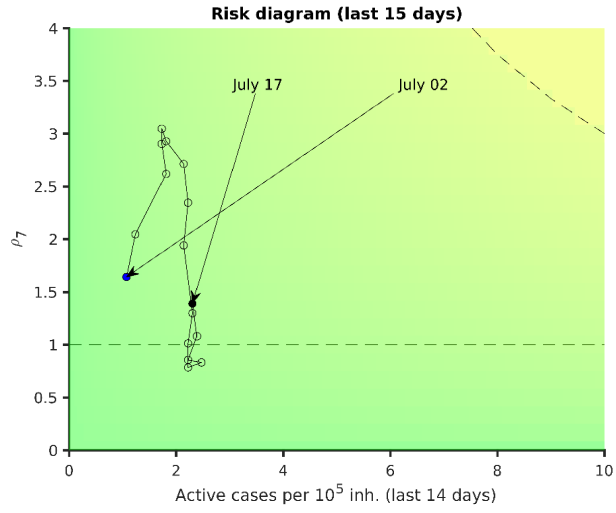




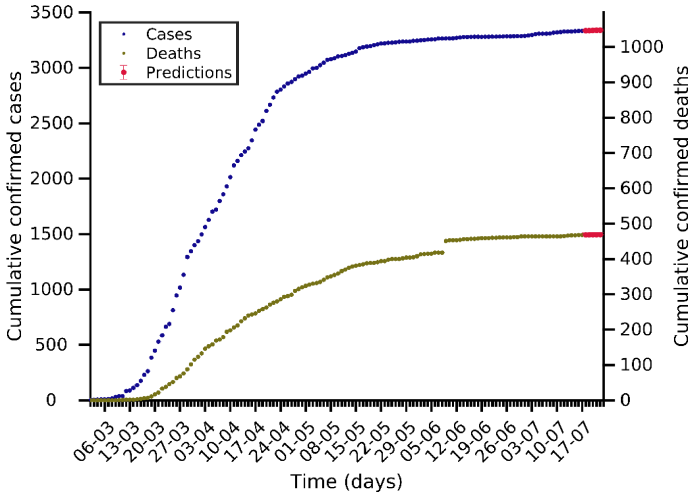


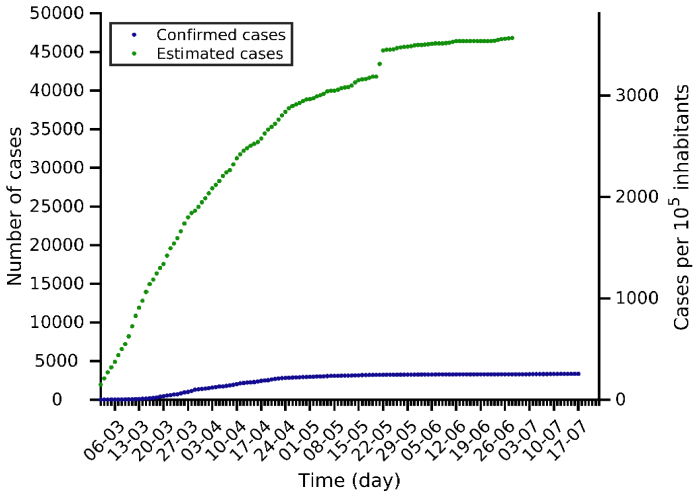


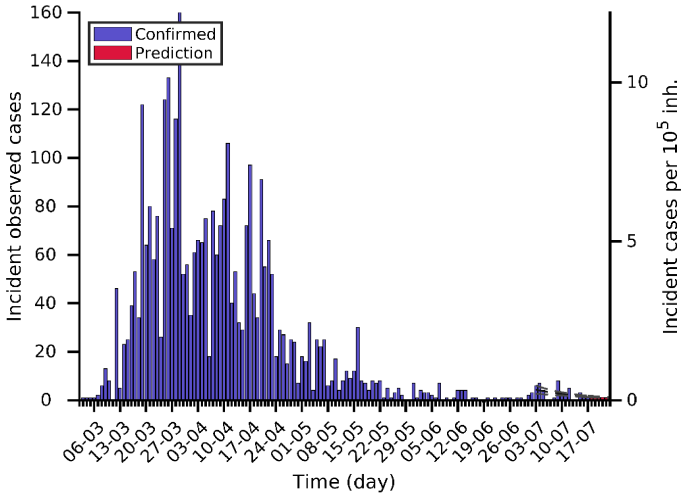


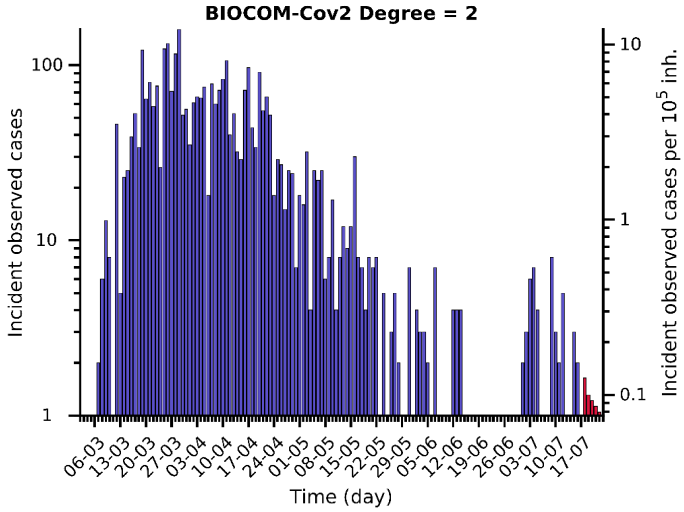


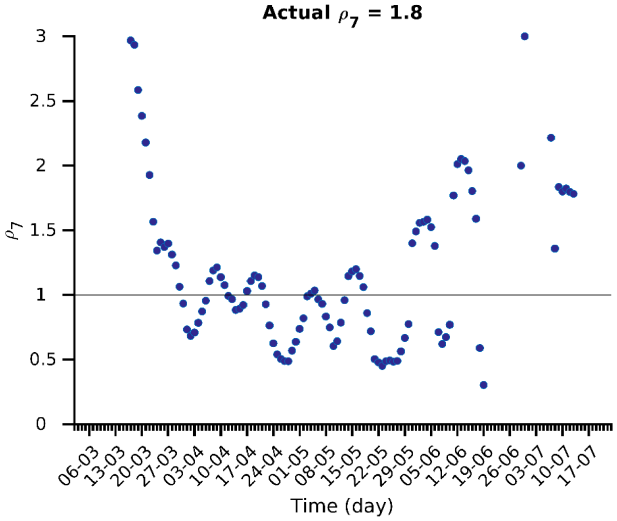
Abruzzo 17-07-2020. Pop: 1.3M. Cumulative incidence: 254/10⁵

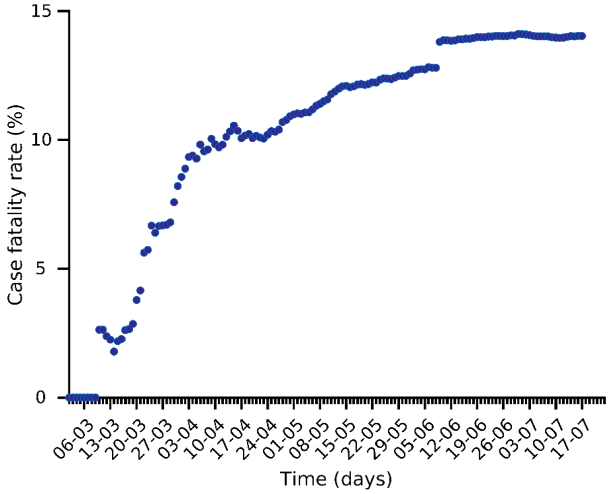


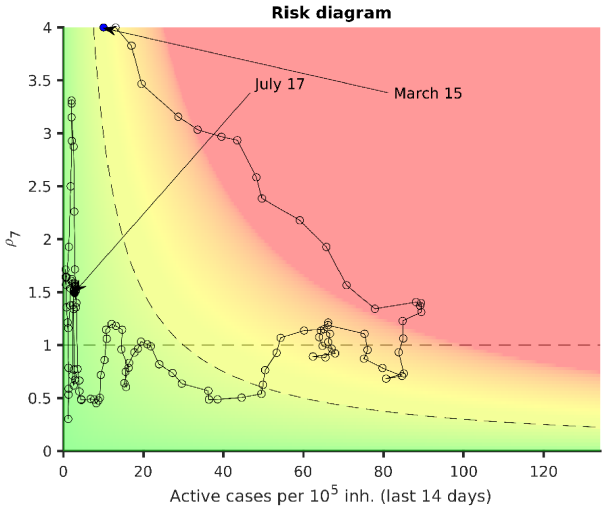


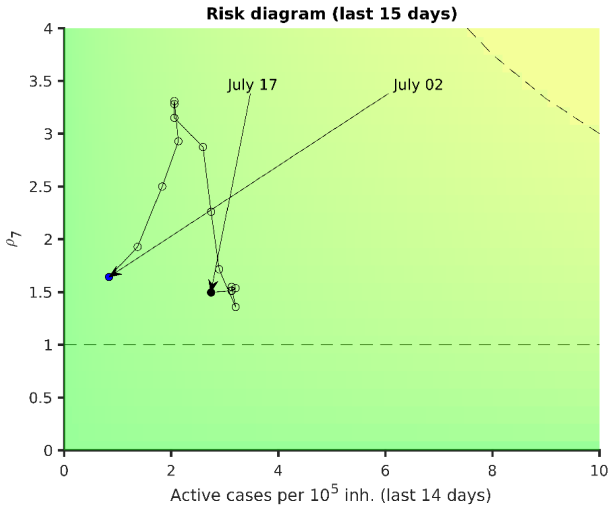




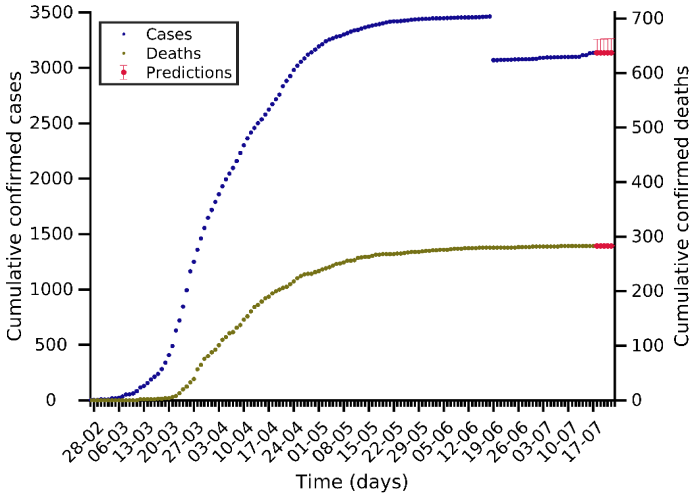


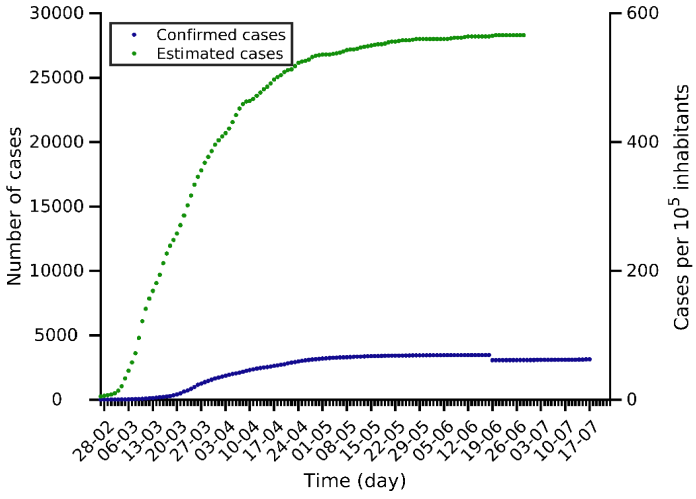


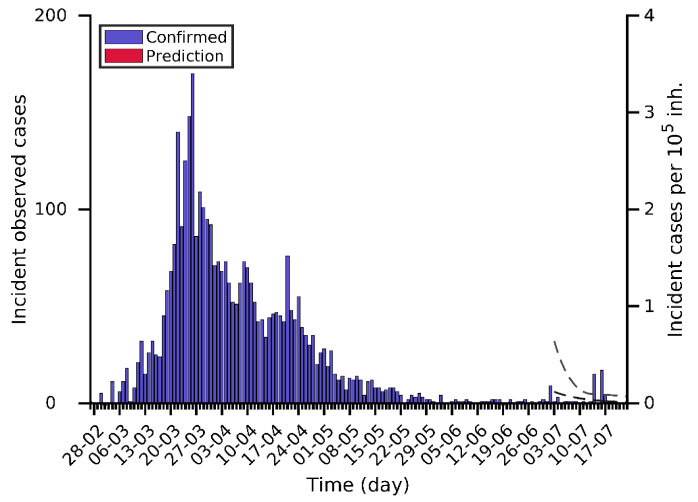


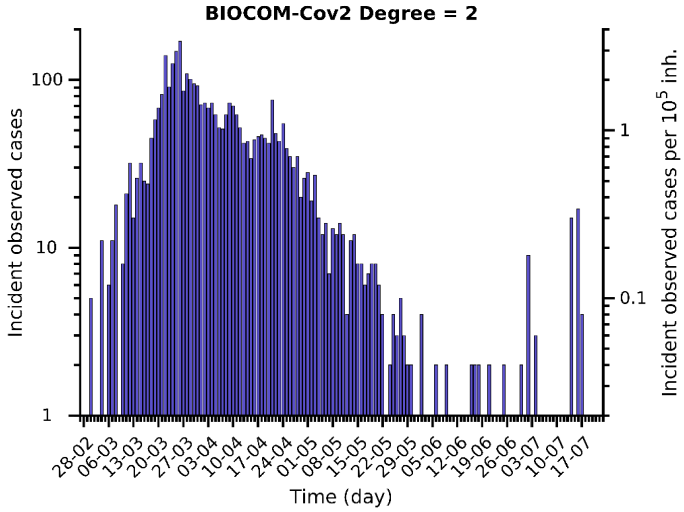


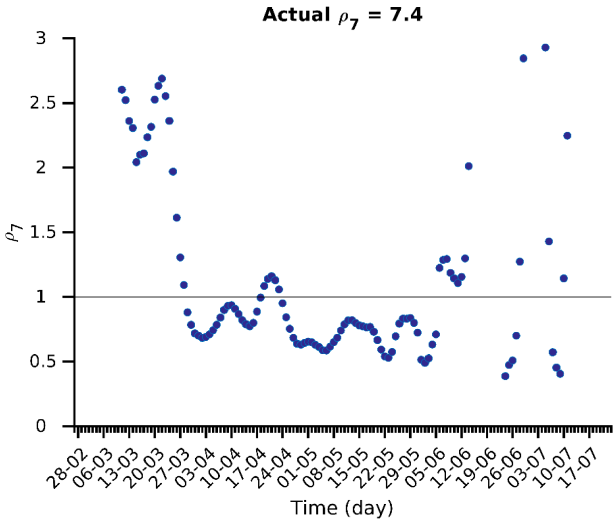
Sicilia 17-07-2020. Pop: 5.0M. Cumulative incidence: 63/10^5

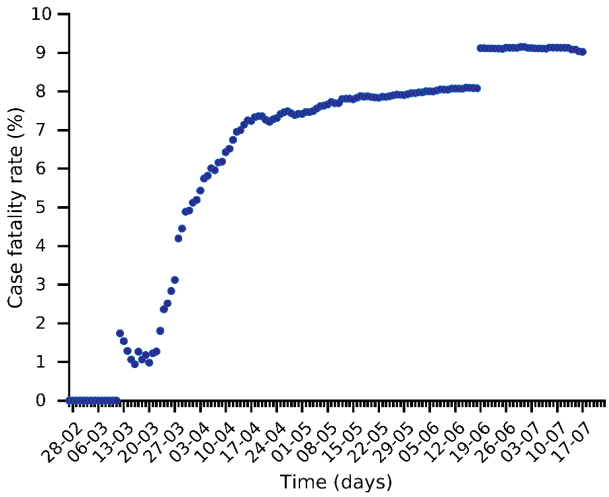


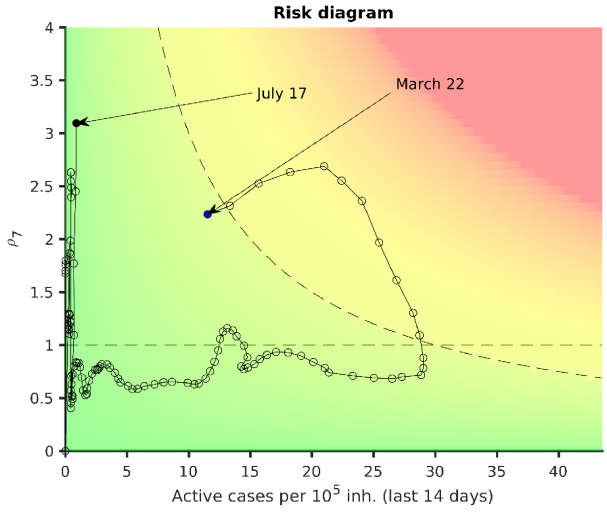


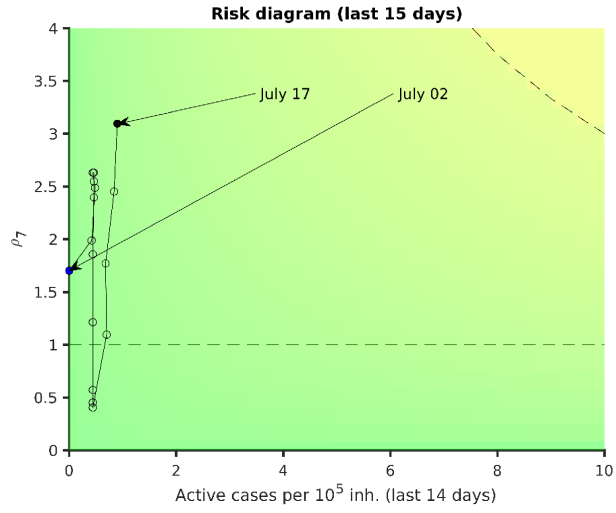




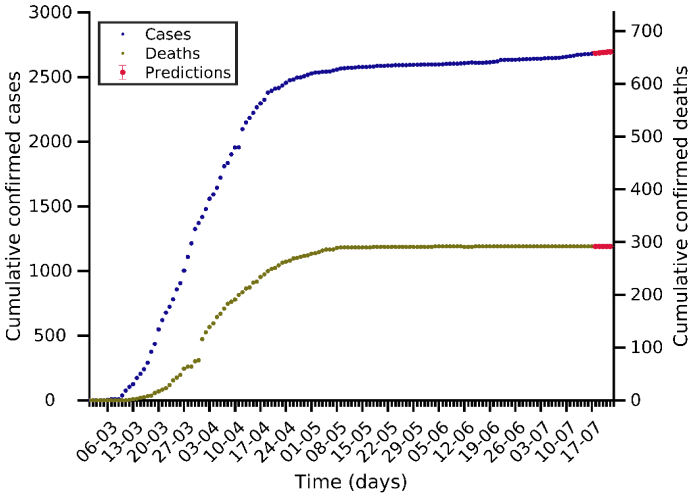


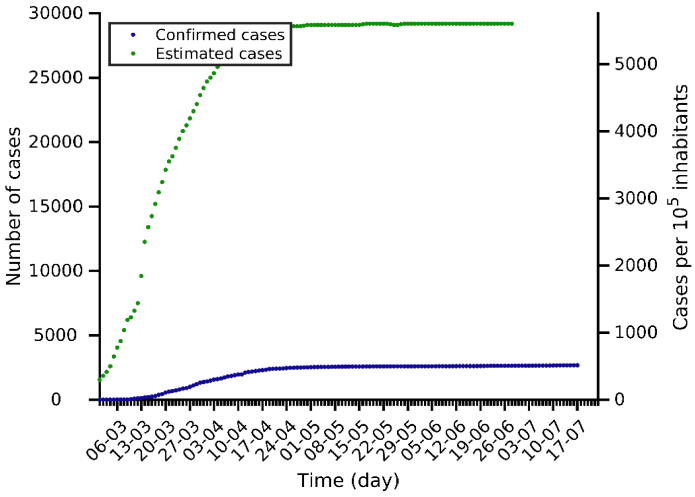


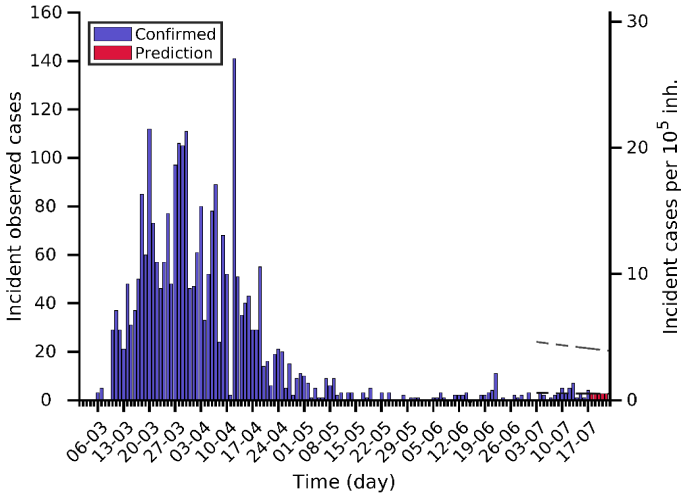


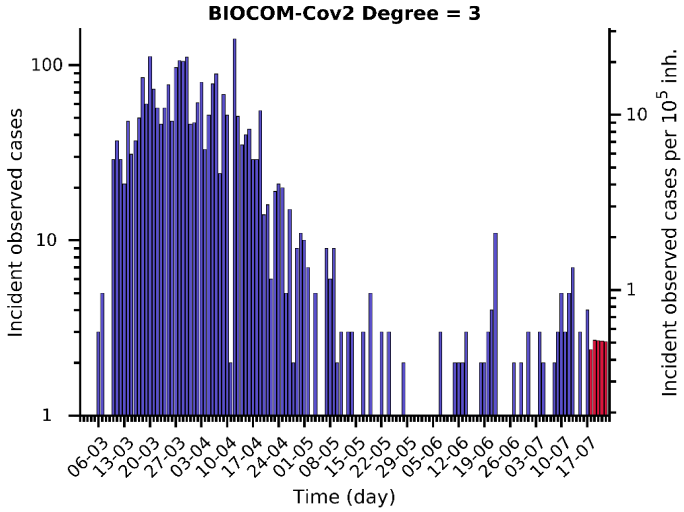


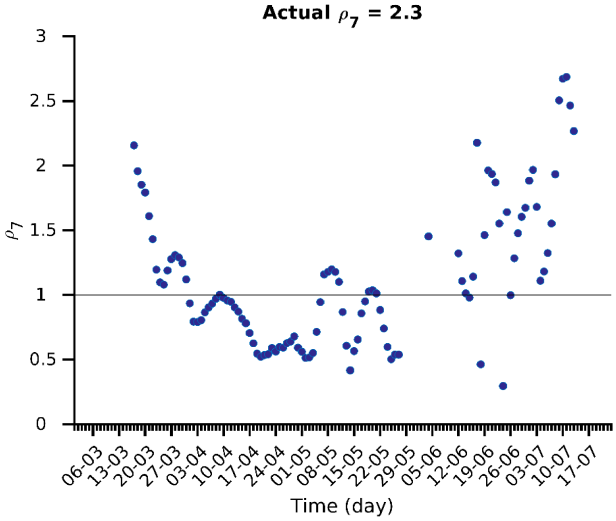
Bolzano 17-07-2020. Pop: 0.5M. Cumulative incidence: 515/10⁵

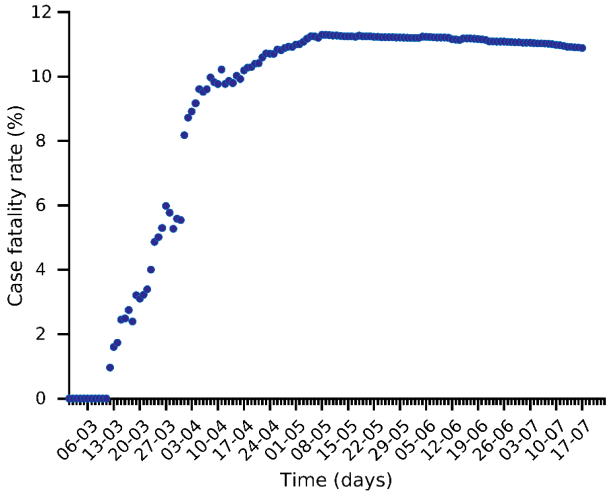


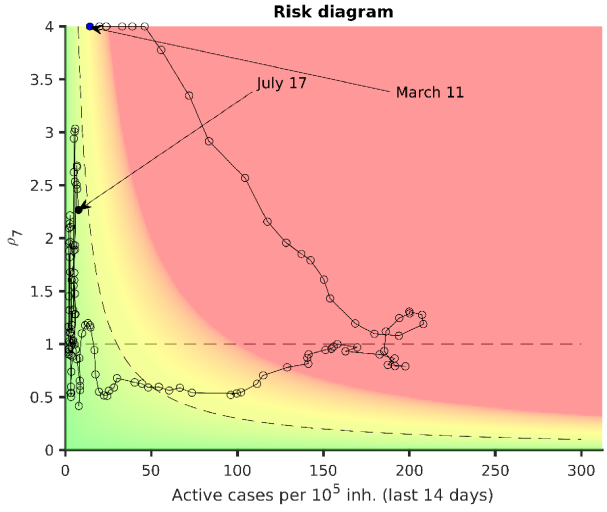


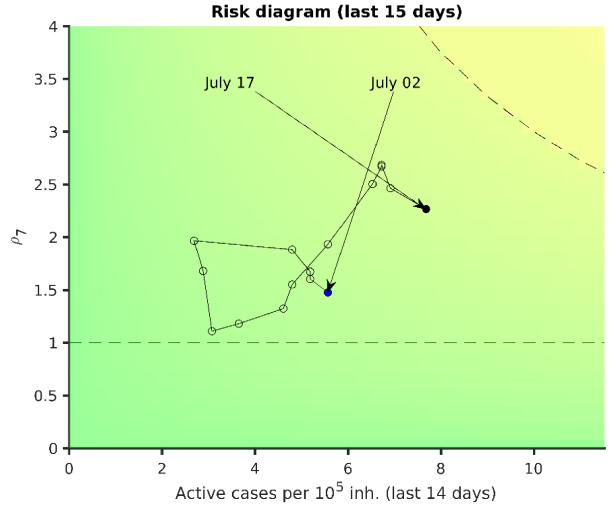




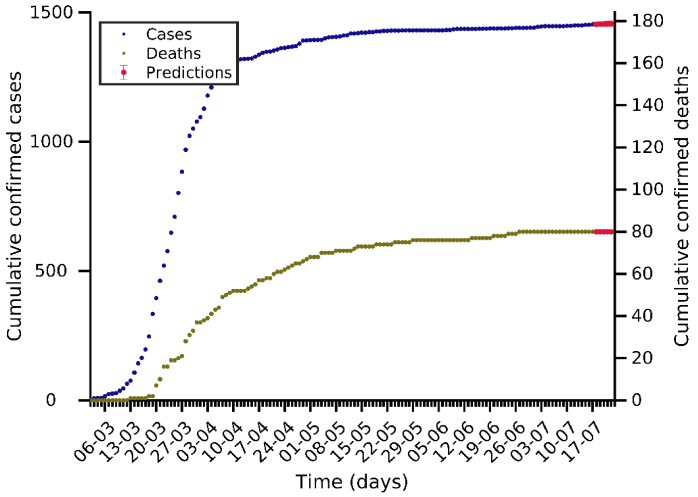


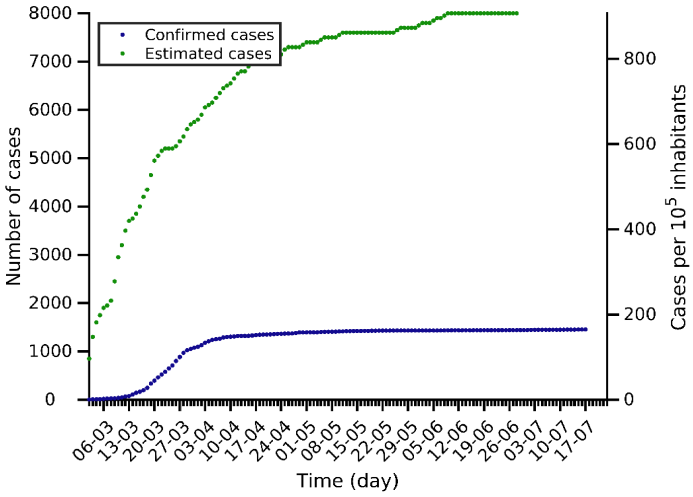


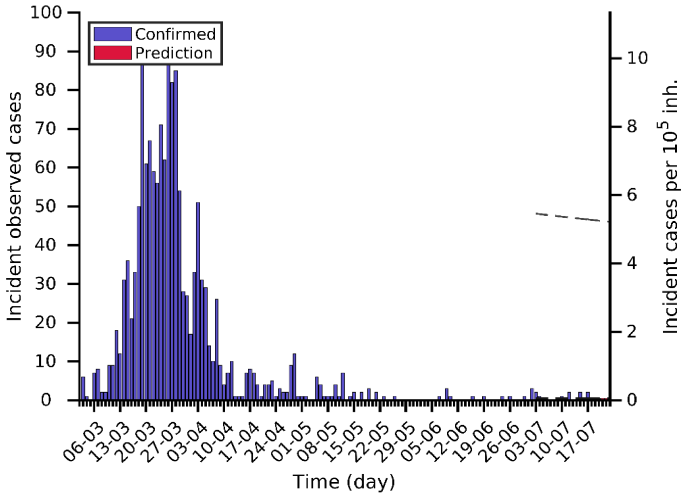


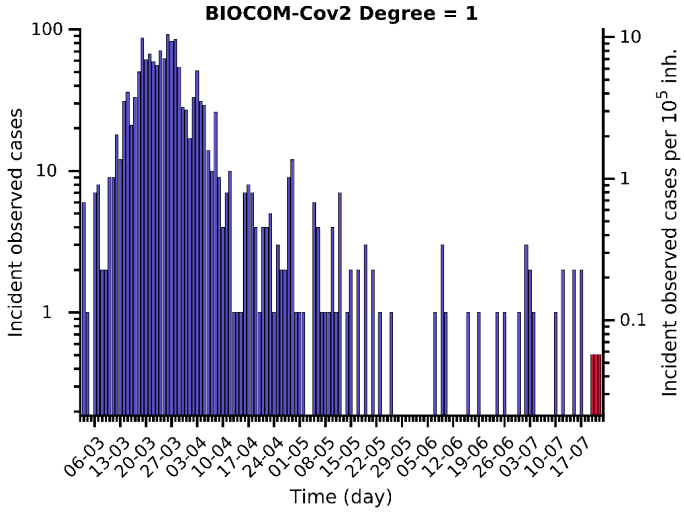


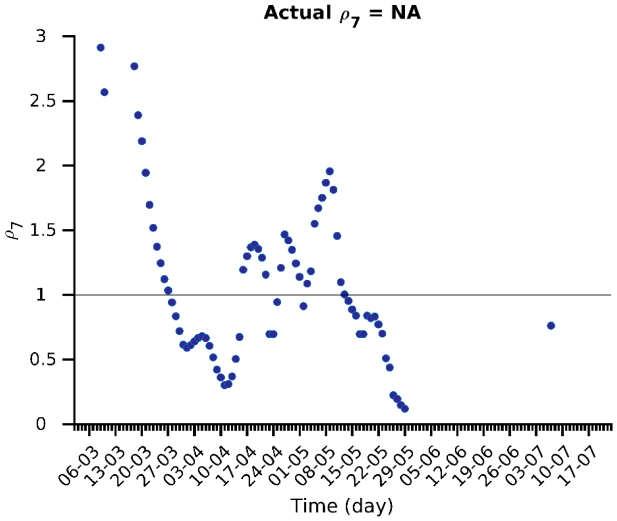
Umbria 17-07-2020. Pop: 0.9M. Cumulative incidence: 165/10⁵

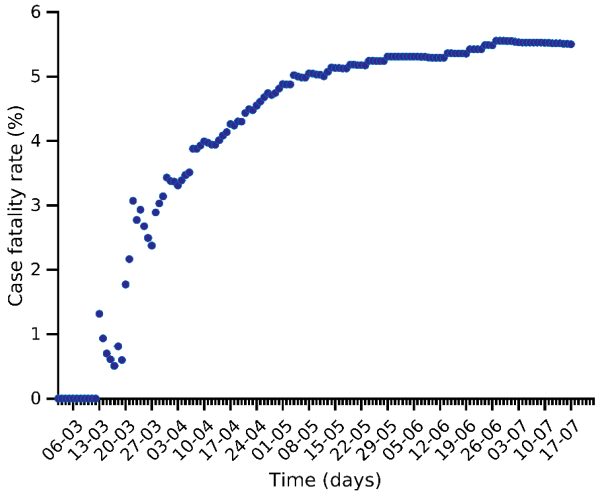


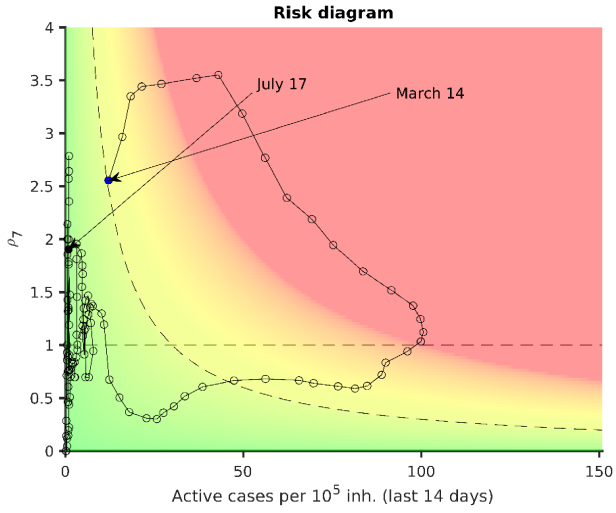


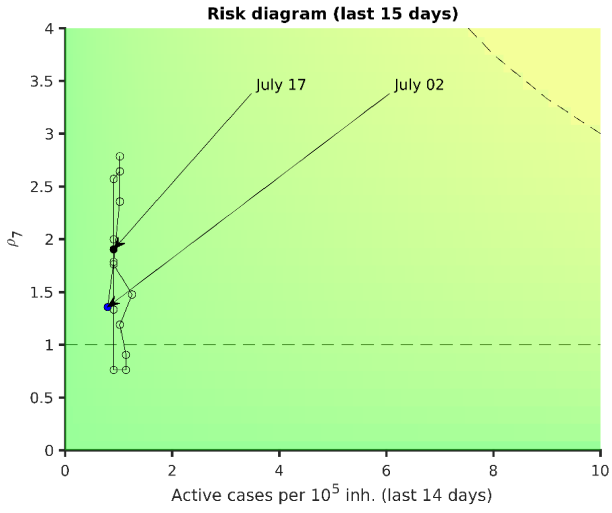




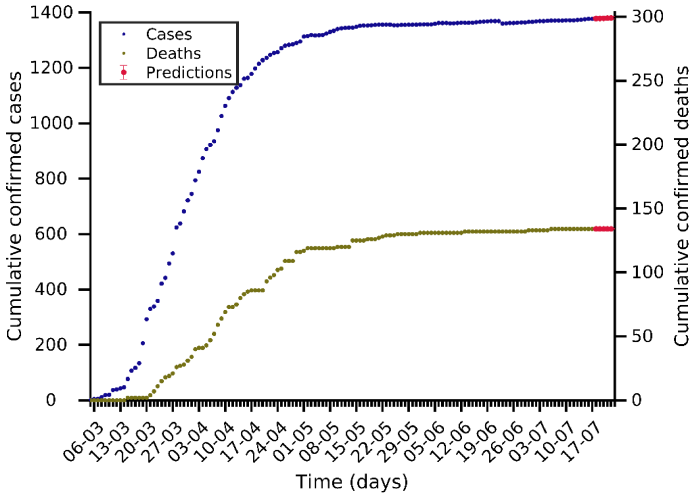


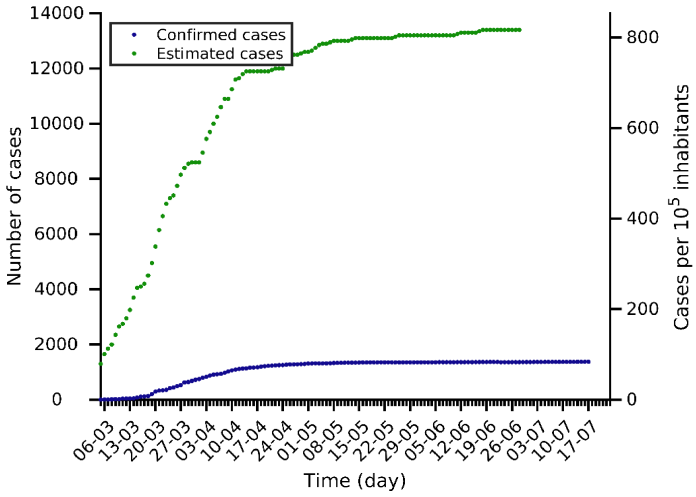


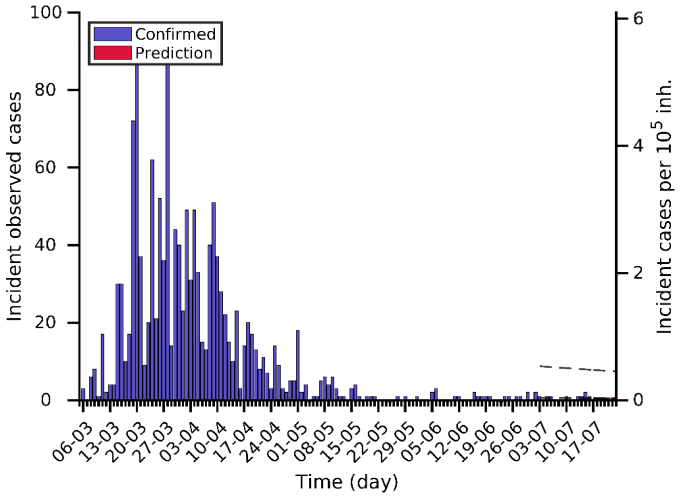


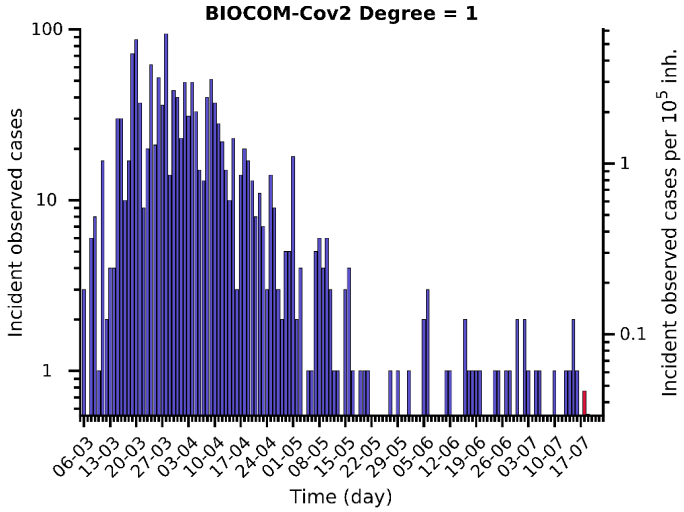


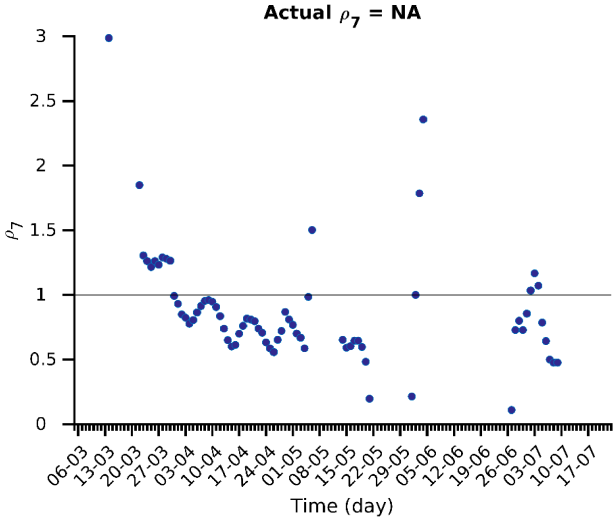
Sardegna 17-07-2020. Pop: 1.6M. Cumulative incidence: 84/10^5

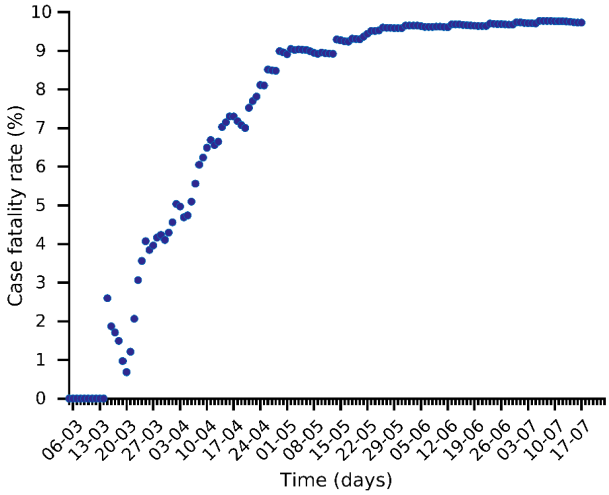


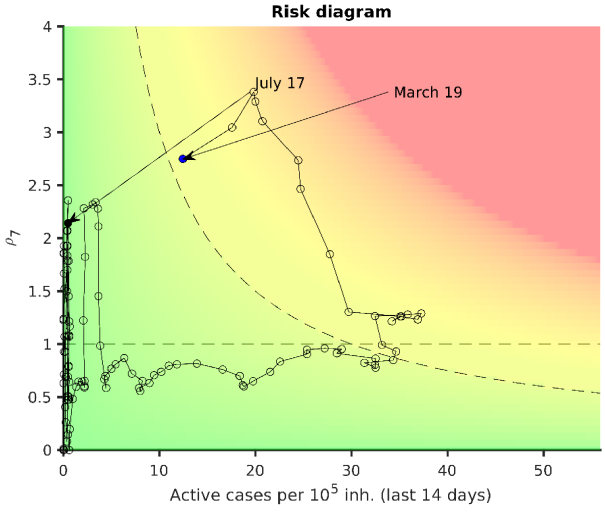


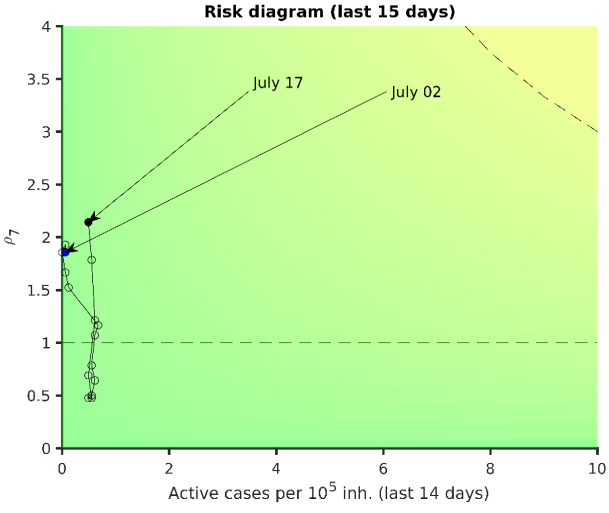




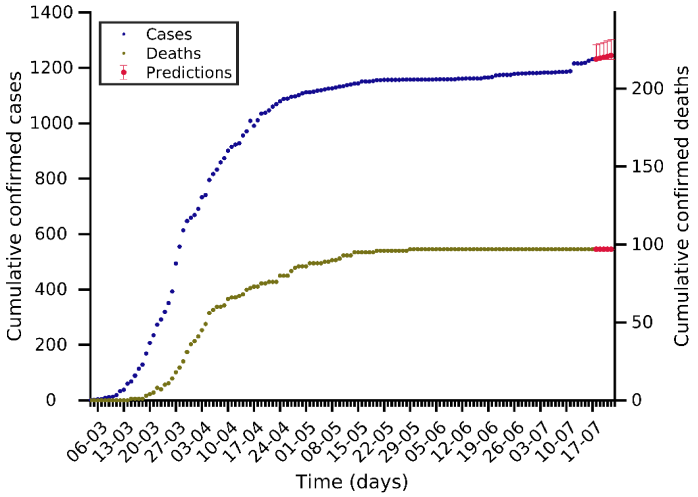


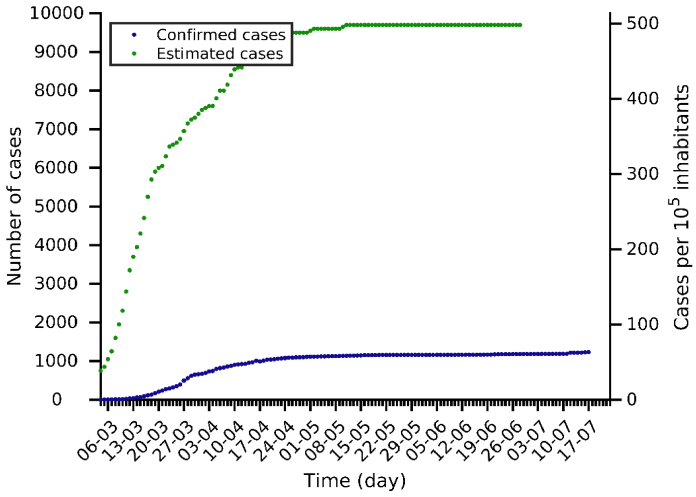


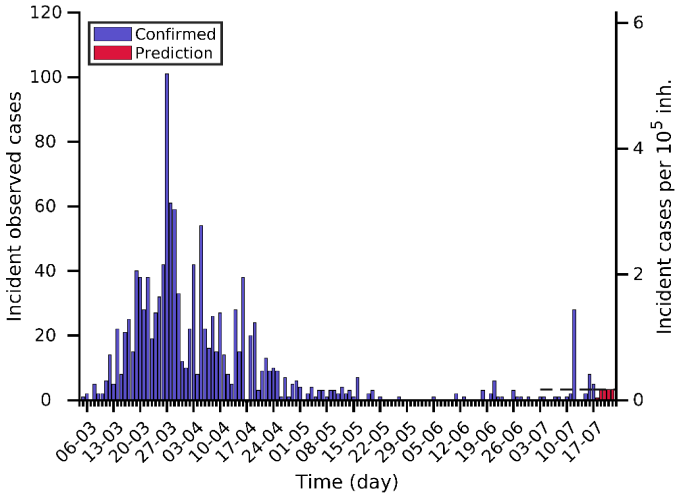


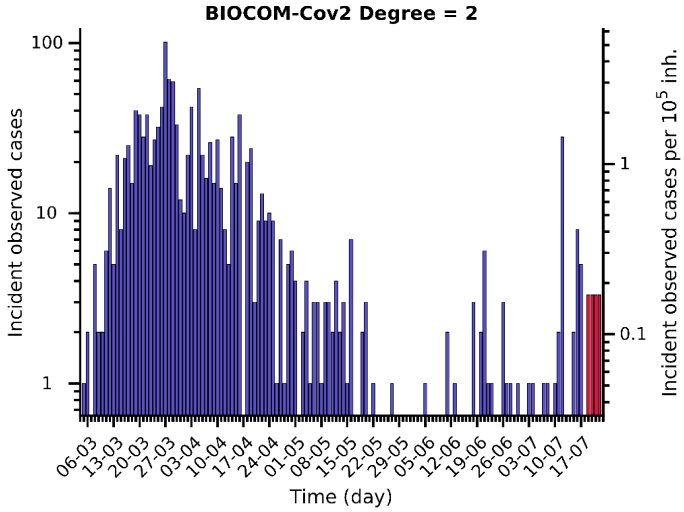


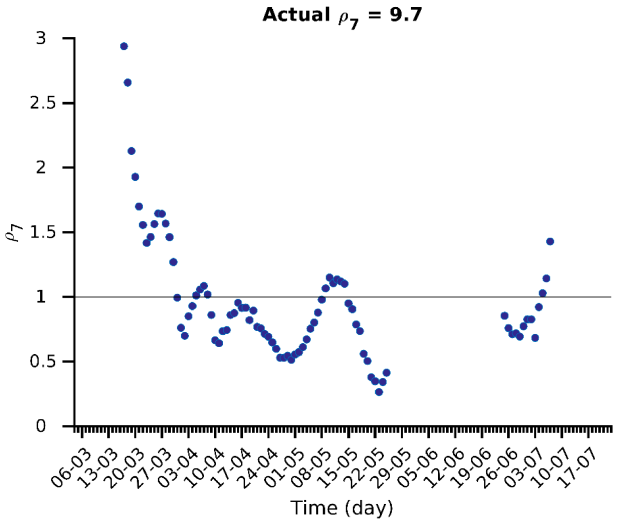
Calabria 17-07-2020. Pop: 1.9M. Cumulative incidence: 63/10^5

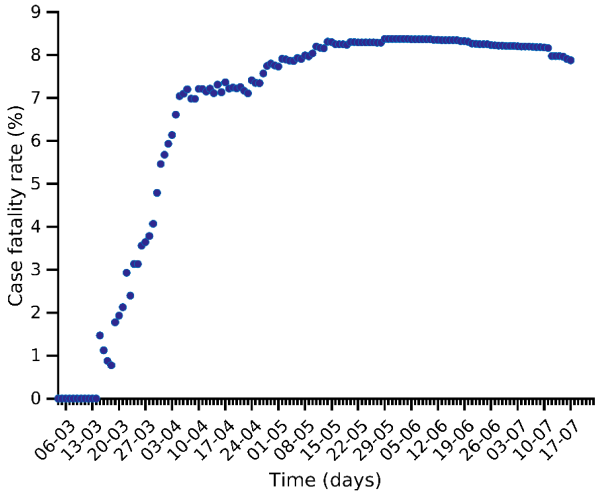


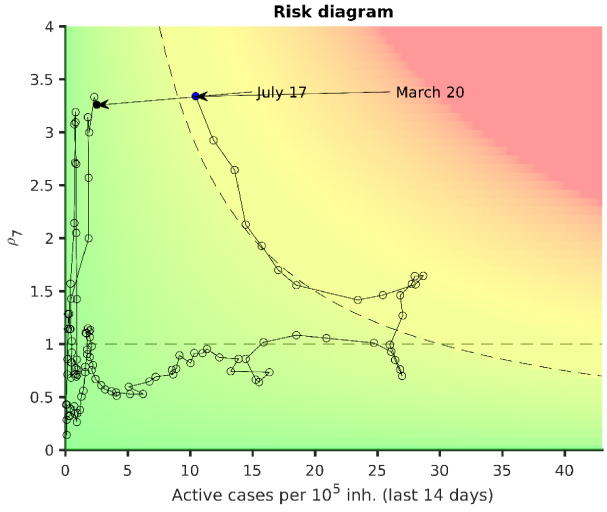


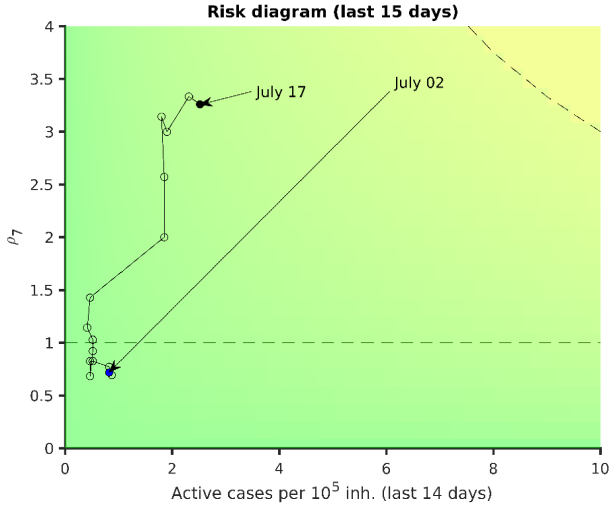




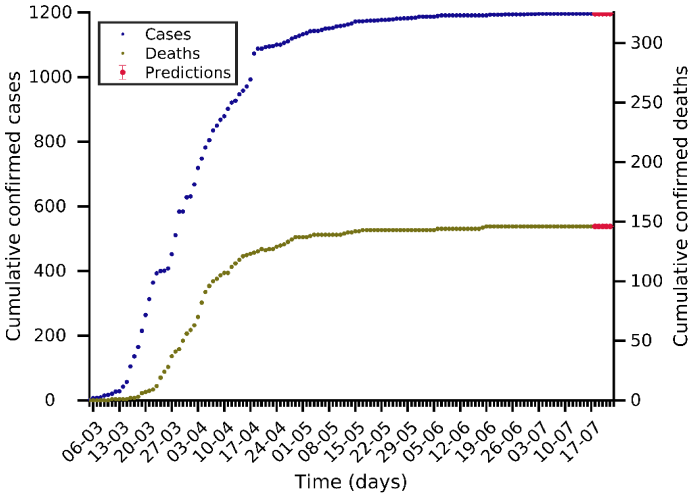


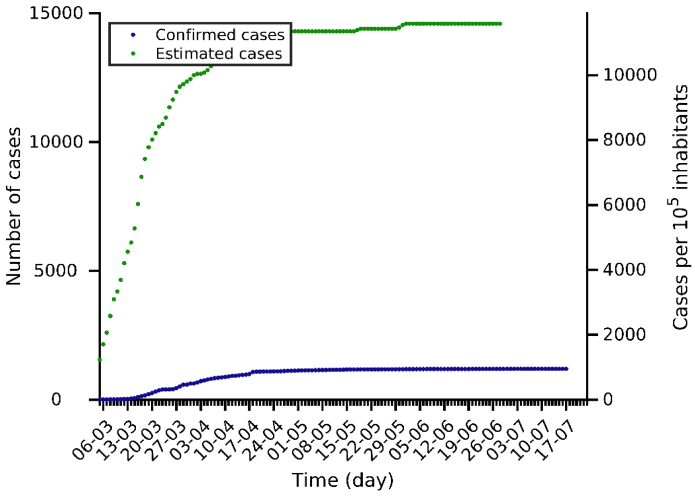


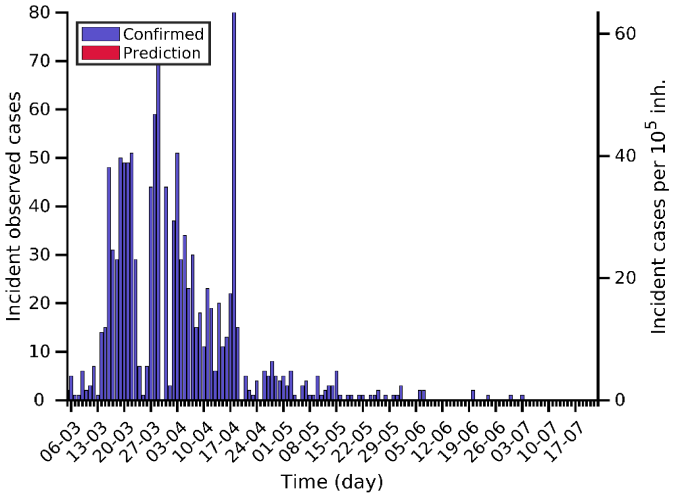


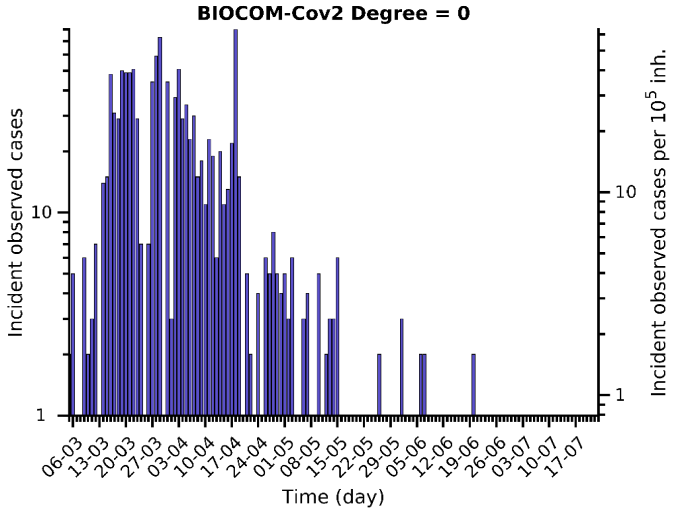


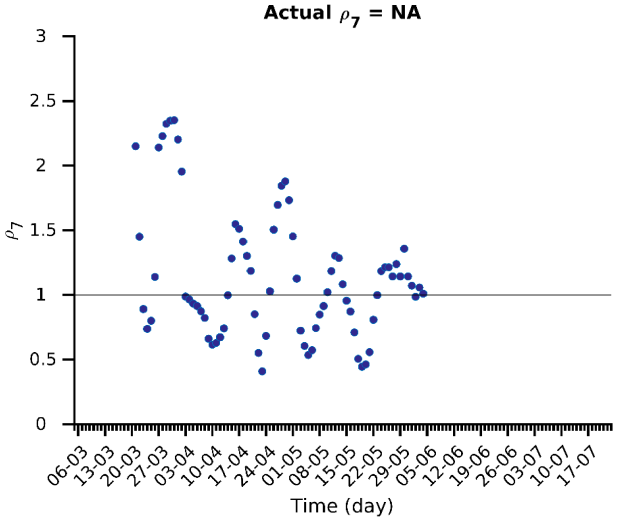
Valle dAosta 17-07-2020. Pop: 0.1M. Cumulative incidence: 949/10⁵

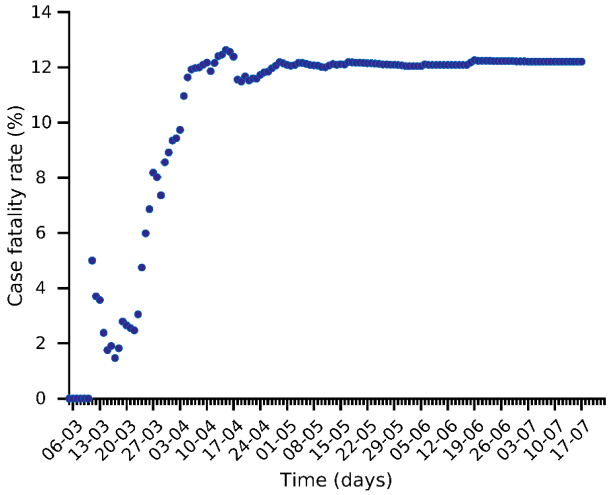


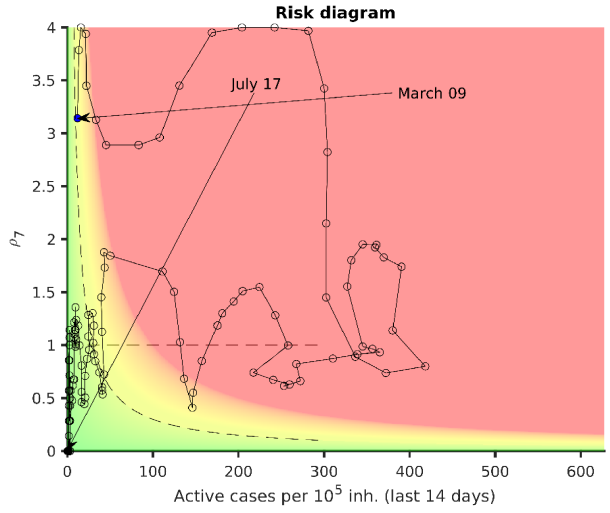


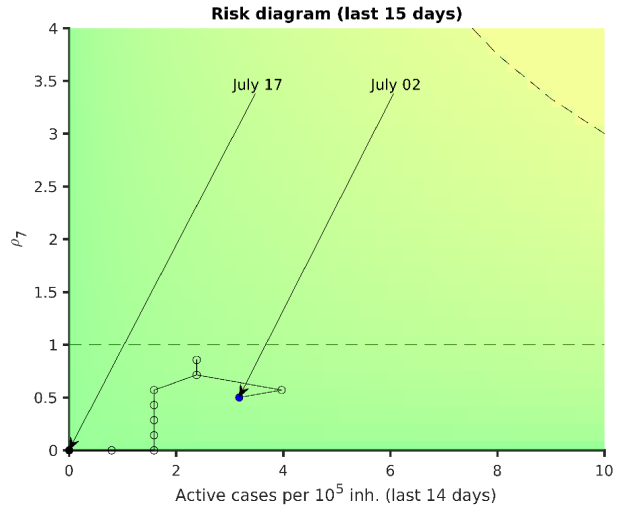




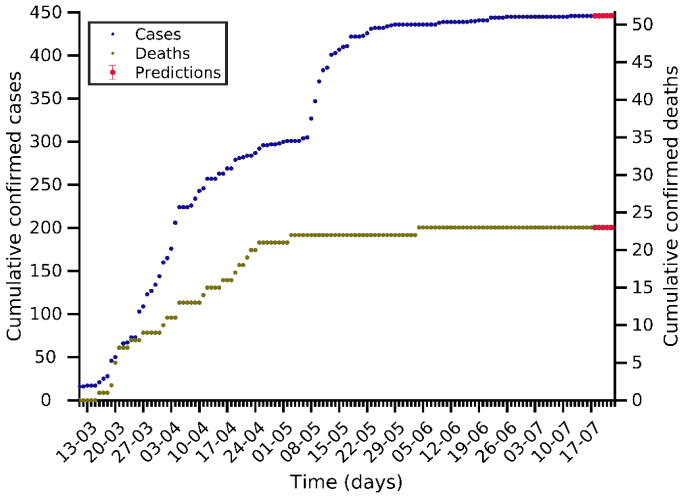


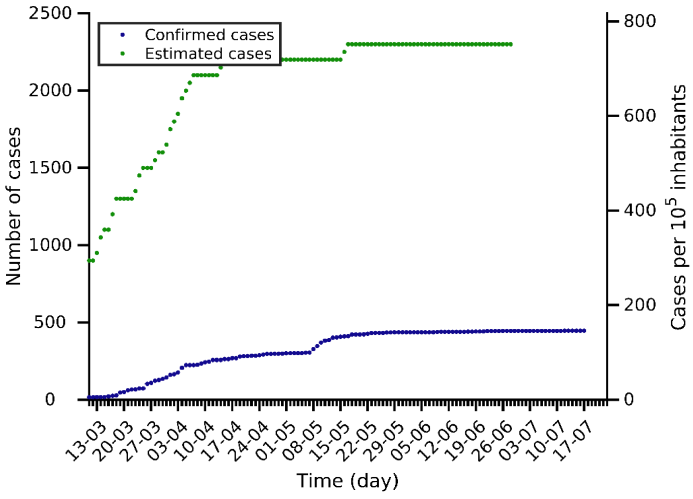


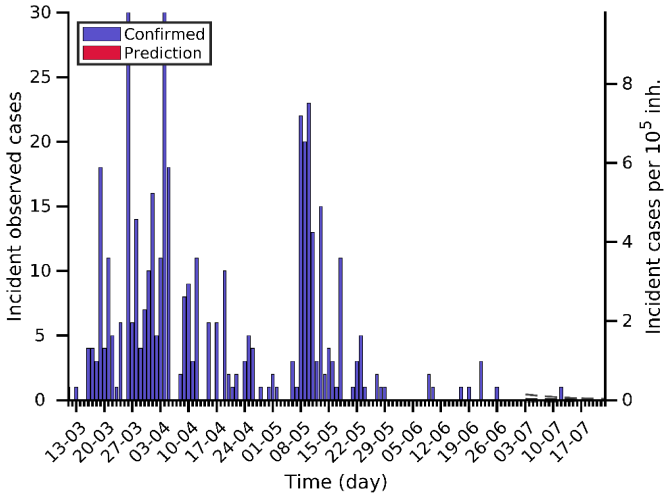


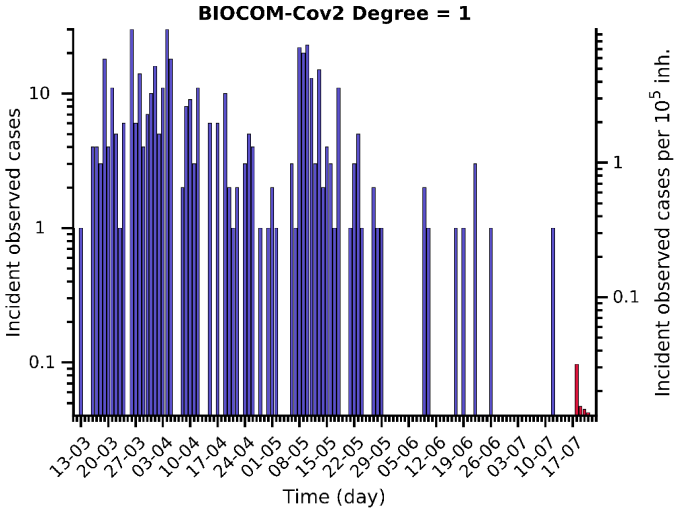


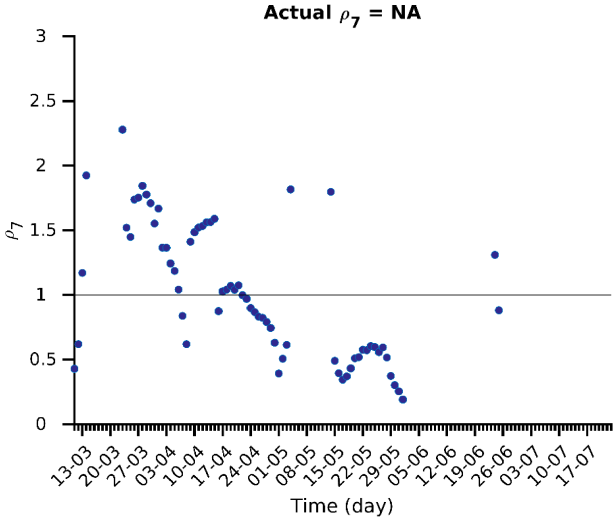
Molise 17-07-2020. Pop: 0.3M. Cumulative incidence: 146/10⁵

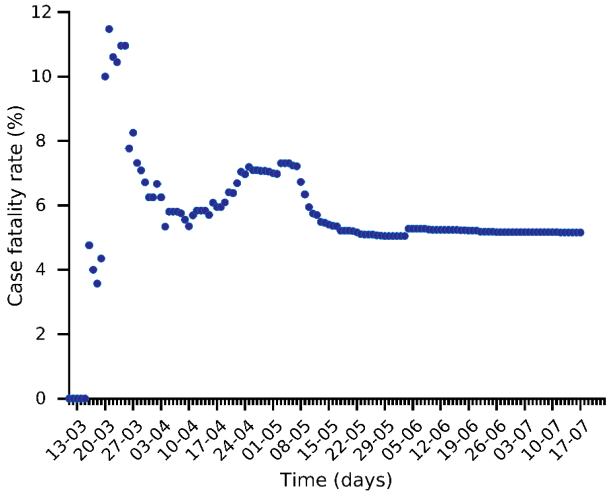


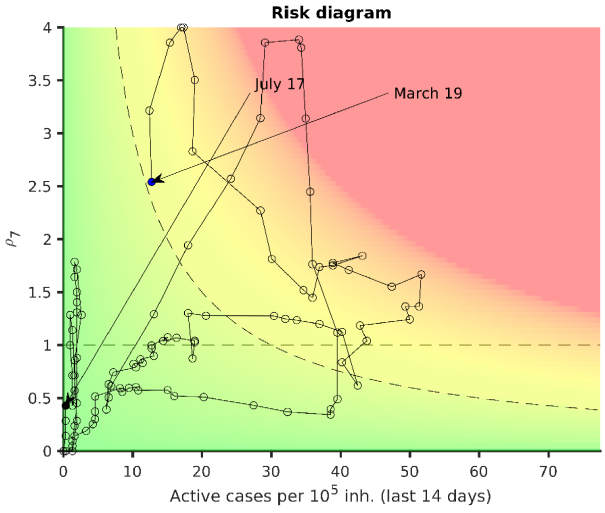


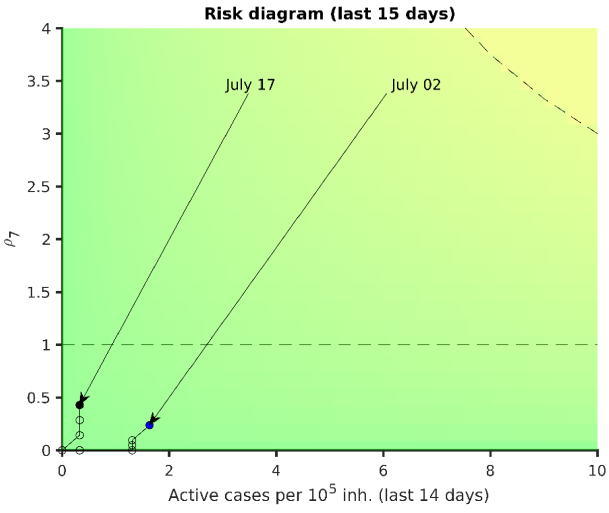




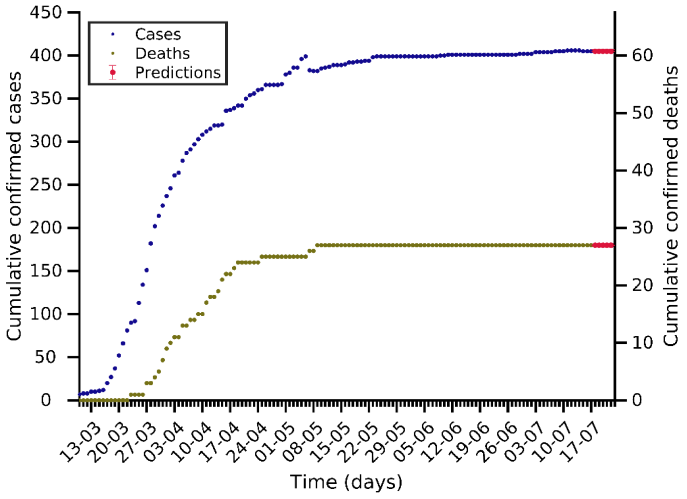


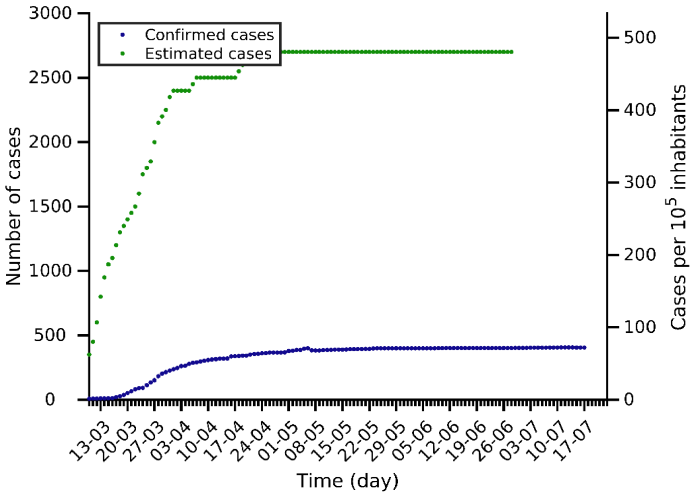


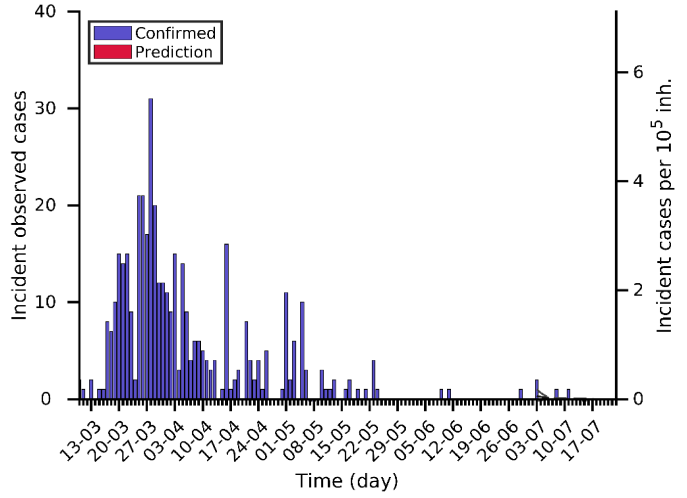


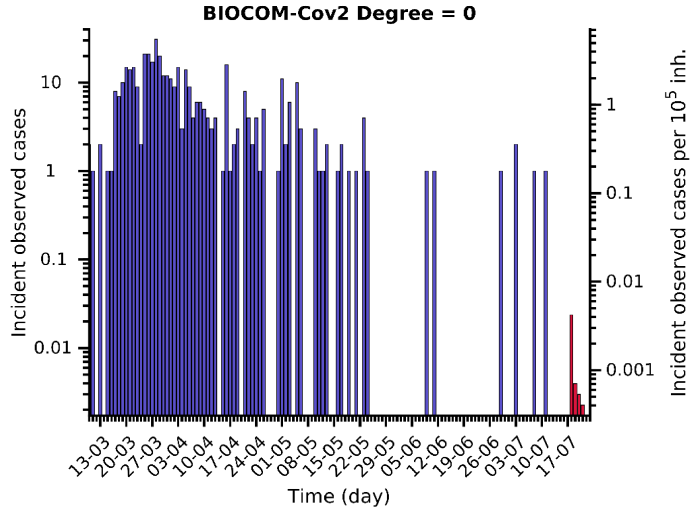


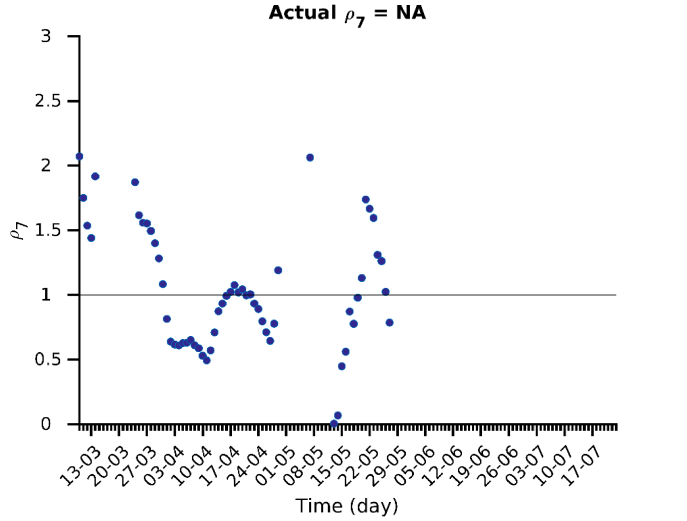
Basilicata 17-07-2020. Pop: 0.6M. Cumulative incidence: 72/10⁵

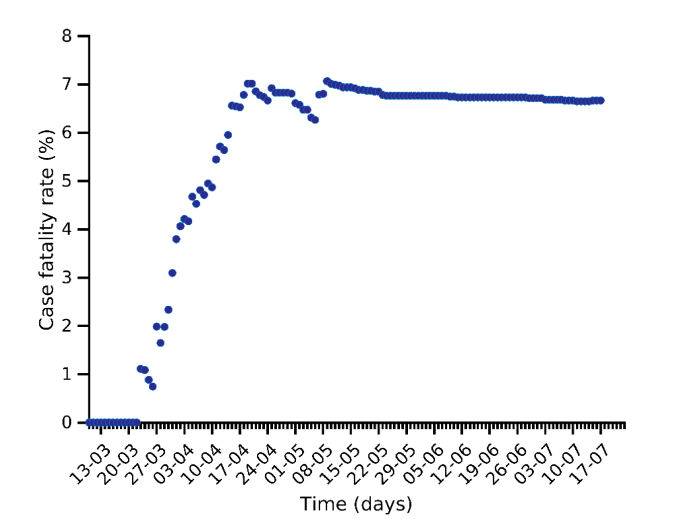


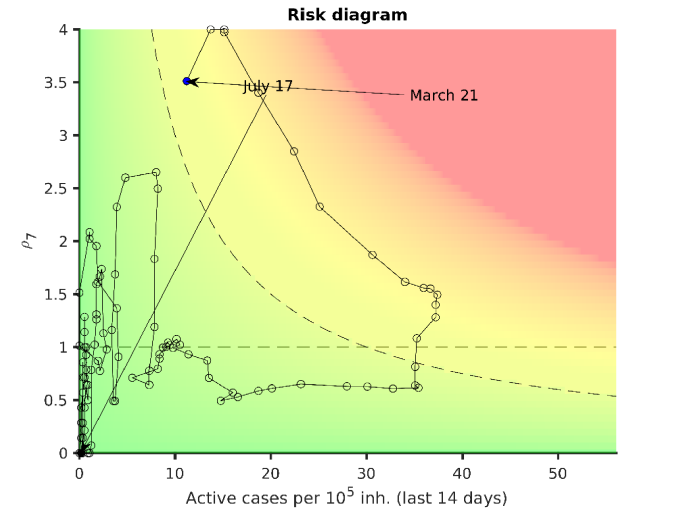


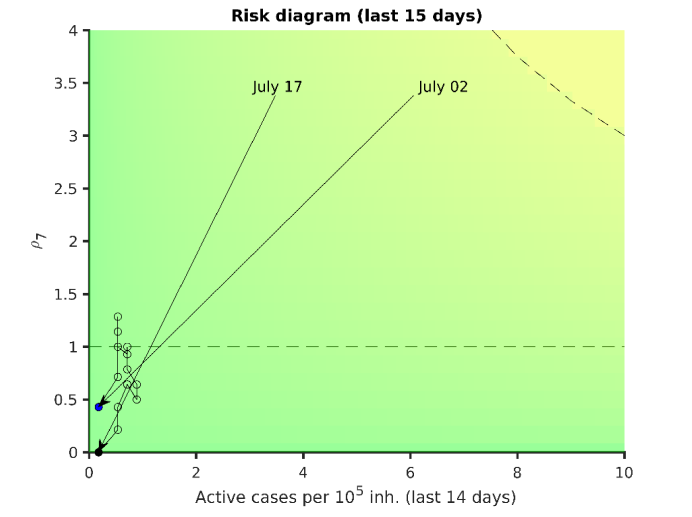












Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports[2], from European Centre for Disease Prevention and Control (ECDC)[3] and from Ministerio de Sanidad[4]. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ: this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report (*t-1*):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day *t*.

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

(I) an initial period where most of the cases are imported;
(II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

[2] https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports
[3] https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases
[4] https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm https://github.com/datadista/datasets/tree/master/COVID%2019 , https://covid19.isciii.es/

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model[5] correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K\, e^{-ln\left(\frac{K}{N_0}\right)\cdot e^{-a\cdot(t-t_0)}}$$

where *N(t)* is the cumulated number of confirmed cases at *t* (in days), and N_0 is the number of cumulated cases the day at day t_0. The model has two parameters:

- ✓ *a* is the velocity at which specific spreading rate is slowing down;
- ✓ *K* is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which *N(t)* overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (*a* and *K*) and the R^2 of the fitting. At the initial stages the dynamics is exponential and *K* cannot be correctly evaluated. In fact, at this stage the most relevant parameter is *a*. Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted *a* with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted *K* with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a>0.2\ day^{-1}$, if $K>10^6$ or if the error in K overpasses 10^6.

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

[5] Madden LV. Quantification of disease progression. Protection Ecology 1980; **2**: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days[6];
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors[7] in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

[6] At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

[7] Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3